Applied ELECTROCARDIOGRAPHY

for

Pediatrician

Basic Principles of ECG

Magdy Abou El-Kheir, MD

Prof of pediatrics & Head of Pediatric Cardiology Unit

Mansoura University Children's Hospital

PART : I

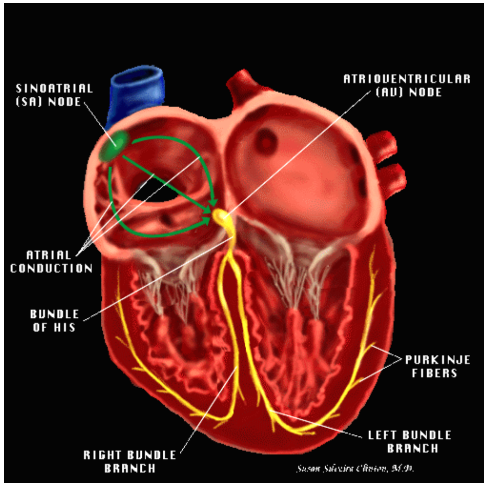
The 5 Requirements for Effective Pumping Action of the Heart:

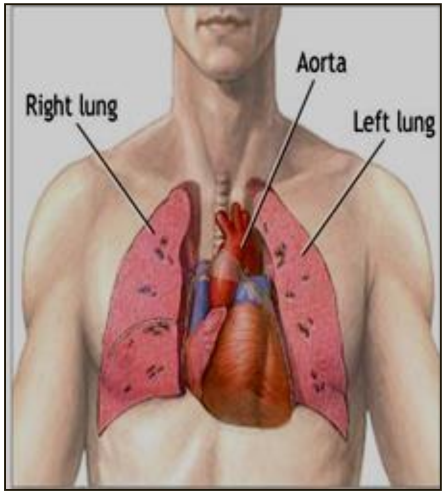
1. The contractions of individual cardiac muscle cells must occur at regular intervals(sequential) and synchronized (*not arrhythmic*).
2. The valves must be open fully (*not stenotic*).
3. The valves must not leak(*not insufficient or regurgitant*)
4. The muscles contractions must be forceful (*not failing*).
5. The ventricles must fill adequately during diastole (*no restriction on filling, normal compliance*).

Learning objectives:

- Cardiac anatomy: cardiac chambers
- Cardiac electrophysiology: conduction system
- Basic principles of the 12-lead ECG.

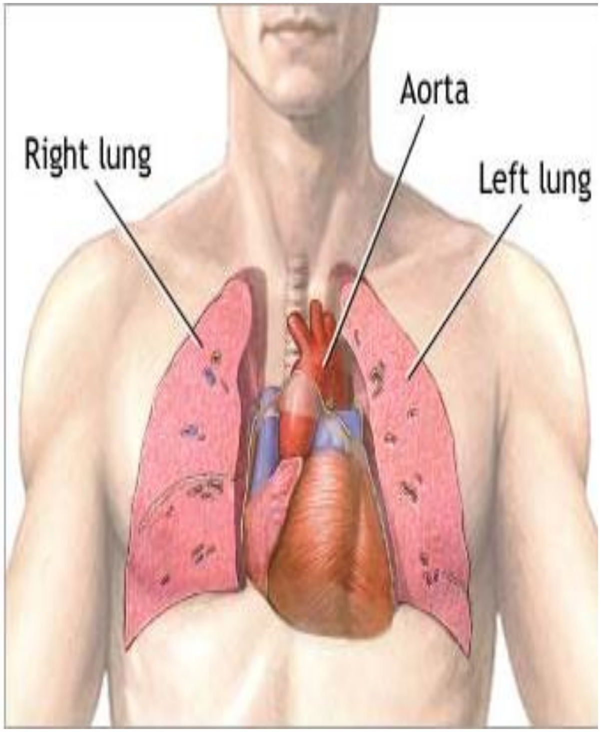
CARDIOVASCULAR ANATOMY AND ELECROPHTYSIOLOGY



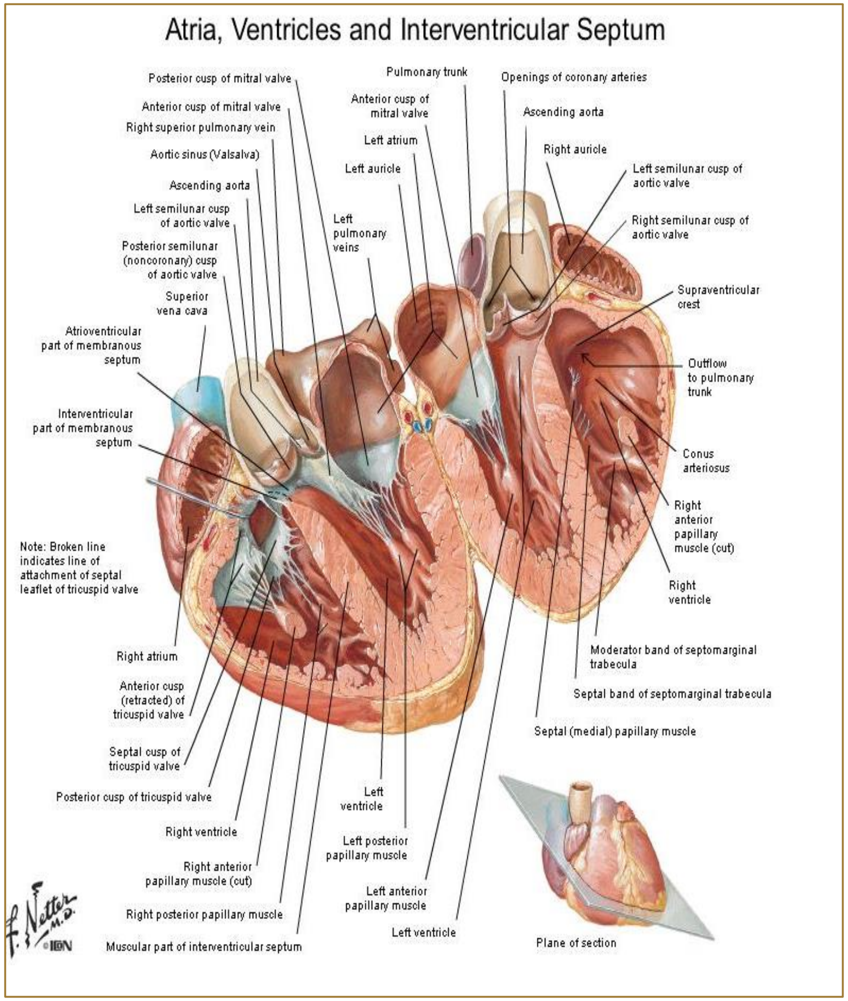


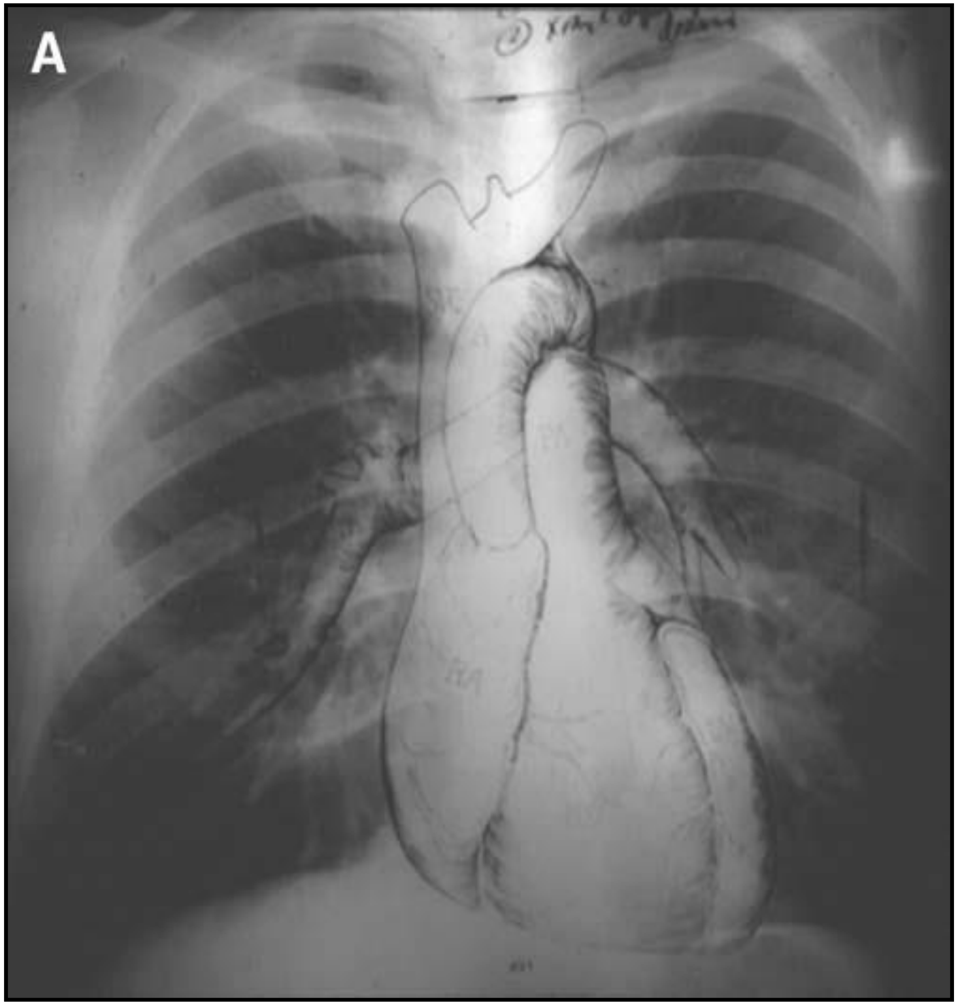
Anatomy of The Heart

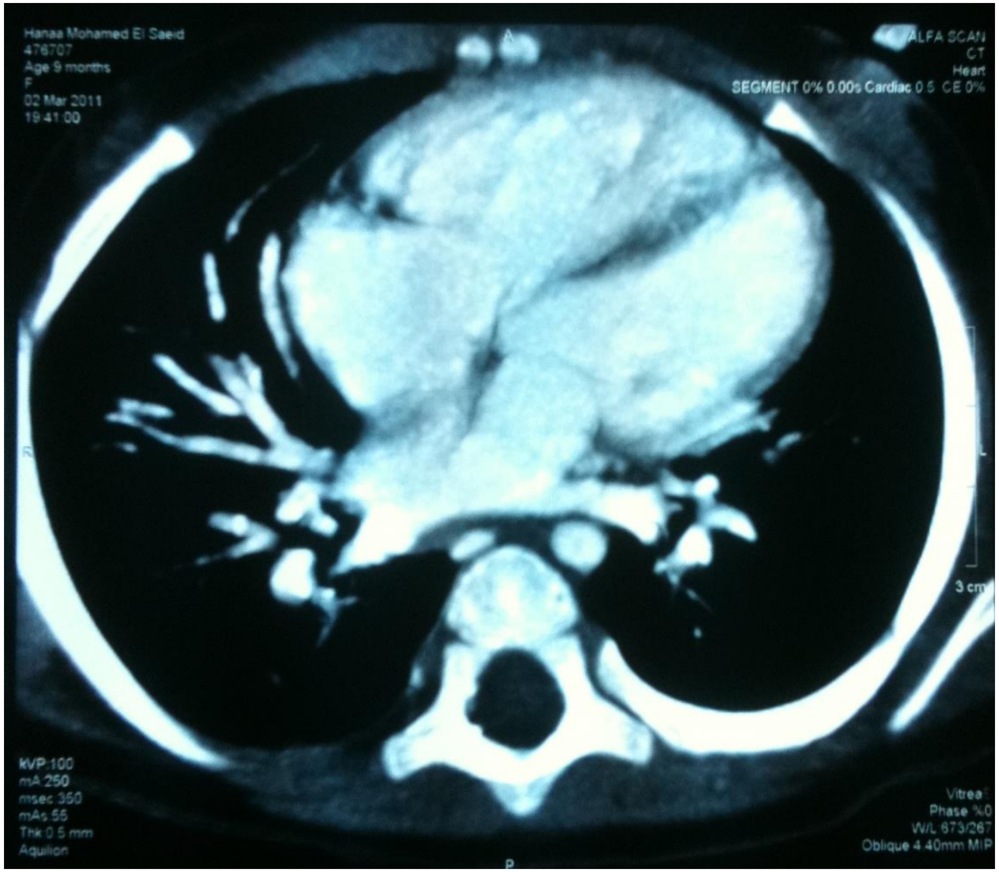
- The apex of the heart is formed by the left ventricle.
- The sternocostal surface of the heart is formed, from right to left, by the right atrium, right ventricle, and left ventricle.
- The diaphragmatic surface of the heart is formed by the right and left ventricles.



Anatomy of The Heart



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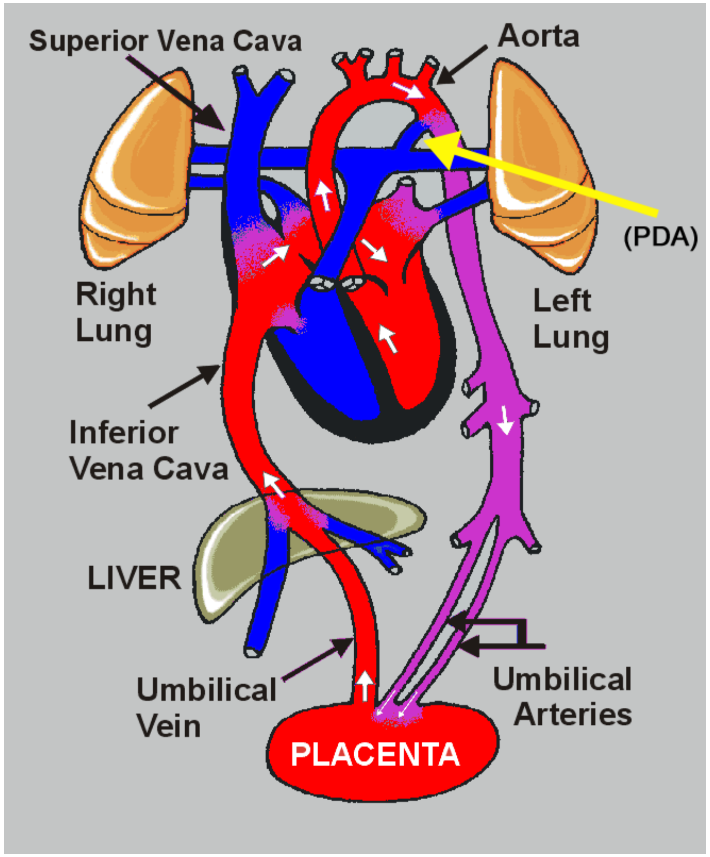
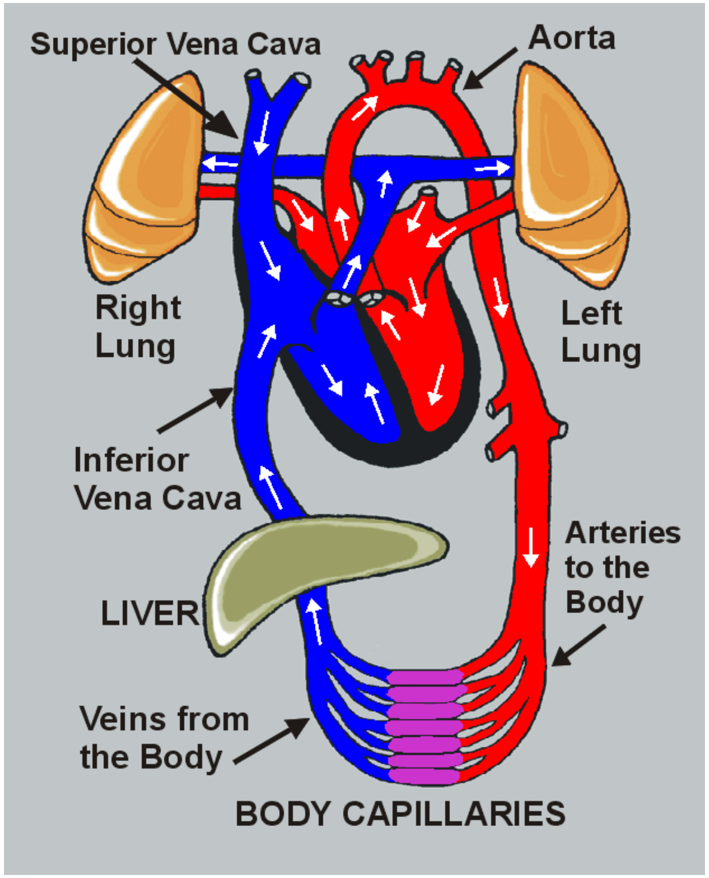
Fetal versus Post-Natal Circulation

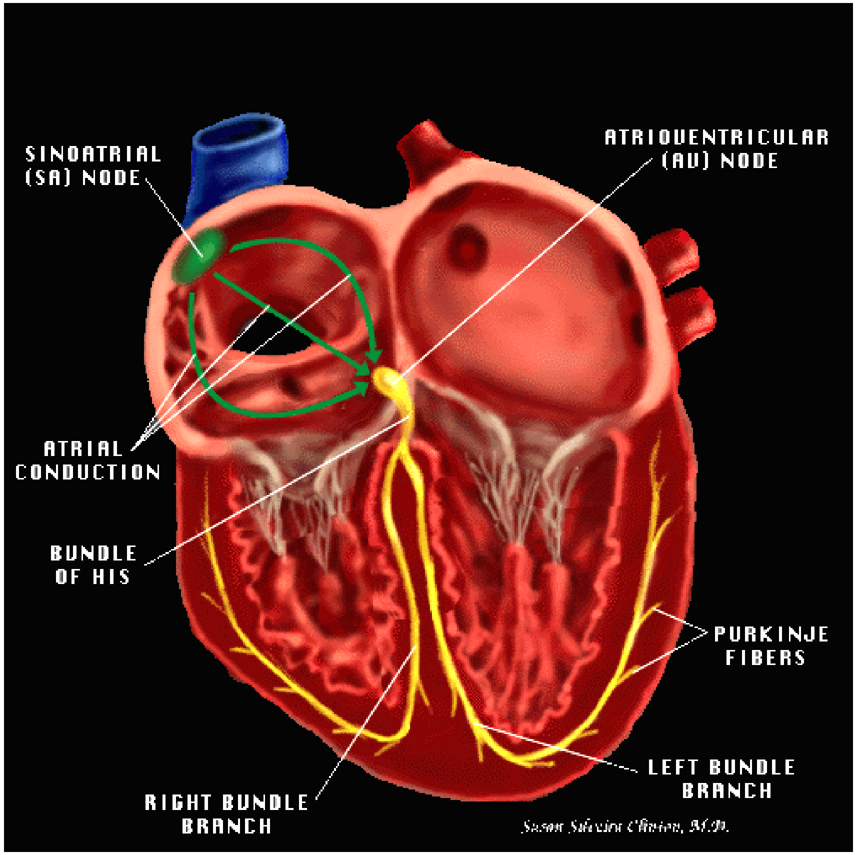


Fetal Circulation



Post-Natal Circulation

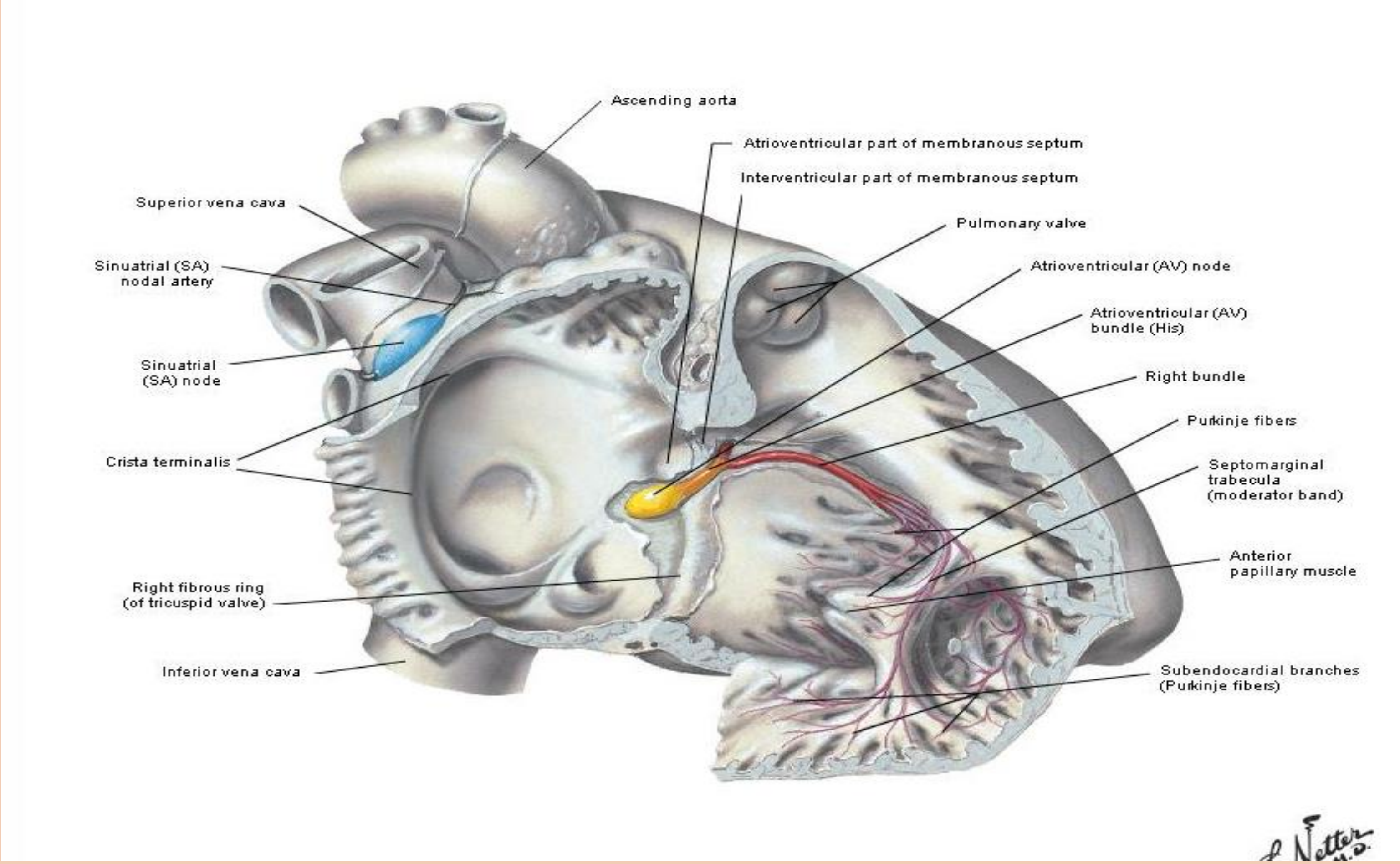
Anatomy of Conduction System



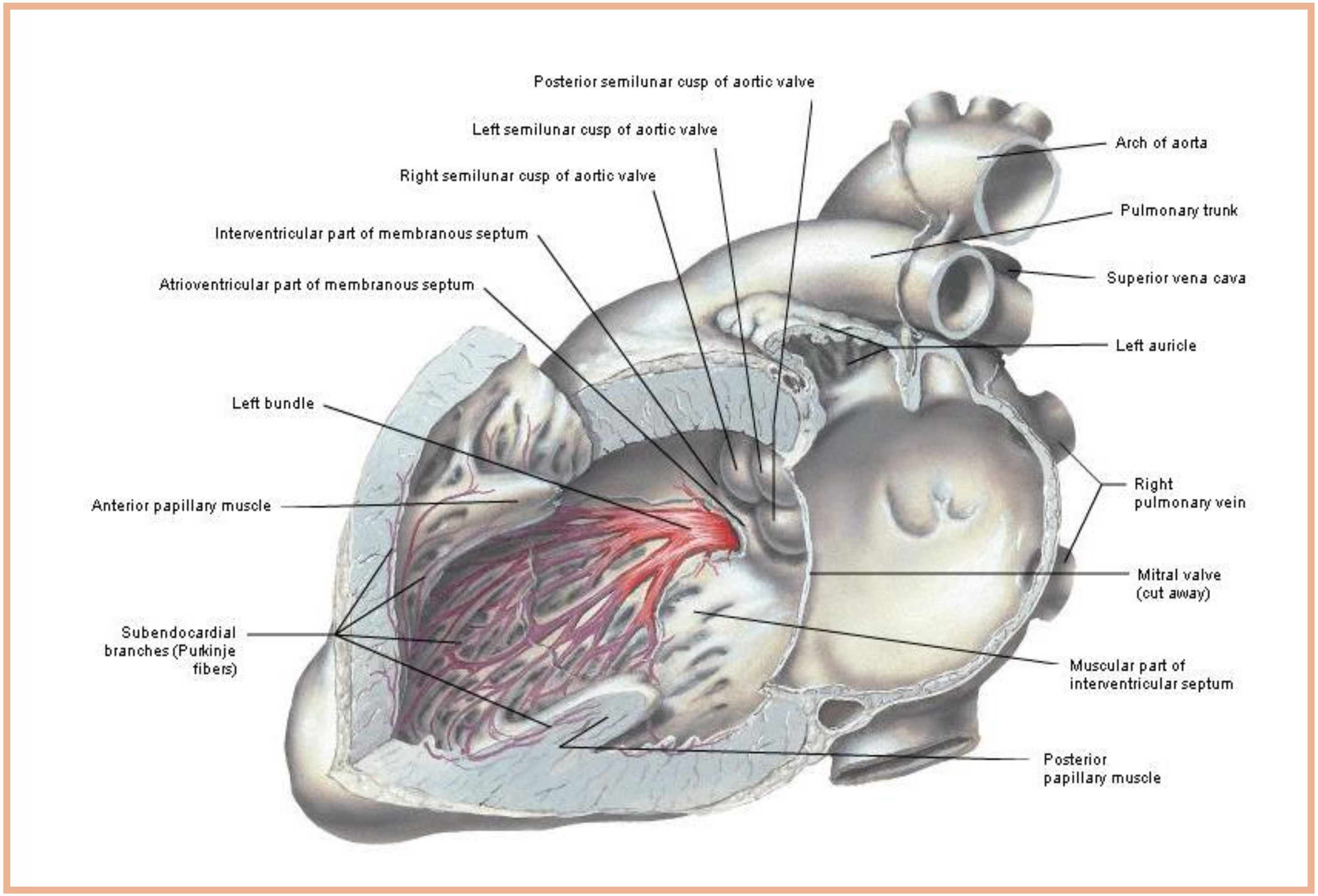
The Definitions of ECG:

- Electrocardiogram (ECG) is the *graphical record* produced by an electrocardiograph .
- Electrocardiograph is the *machine* that records the electrical activity of the heart over time.

Conducting system :Right side



Conducting System :left side



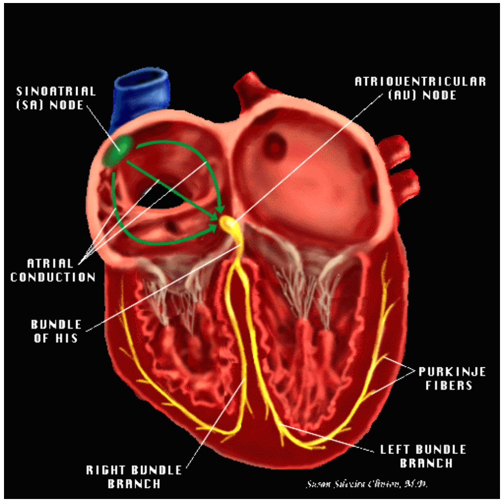
A well-functioning electrical system is vital for adequate cardiac performance :

- **Heart rate regulation :**

- inherited automaticity and autonomic variability).

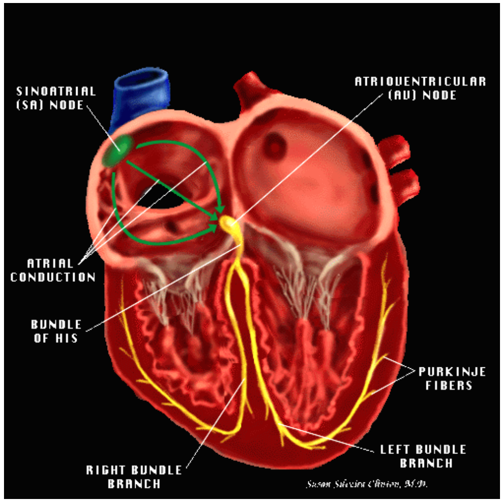
- **Sequence of muscle contraction**:

- Atrial systole.
- A delay .
- Ventricular systole (Apex to base, interior to exterior myocardium)



Localized Variations in the Heart’s Electrical System :

- SAN and AVN are richly supplied by sympathetic and Parasympathetic fibers .
- Rest of the heart’s electrical system (have abundant sympathetic Innervations and sparse parasympathetic Innervations.



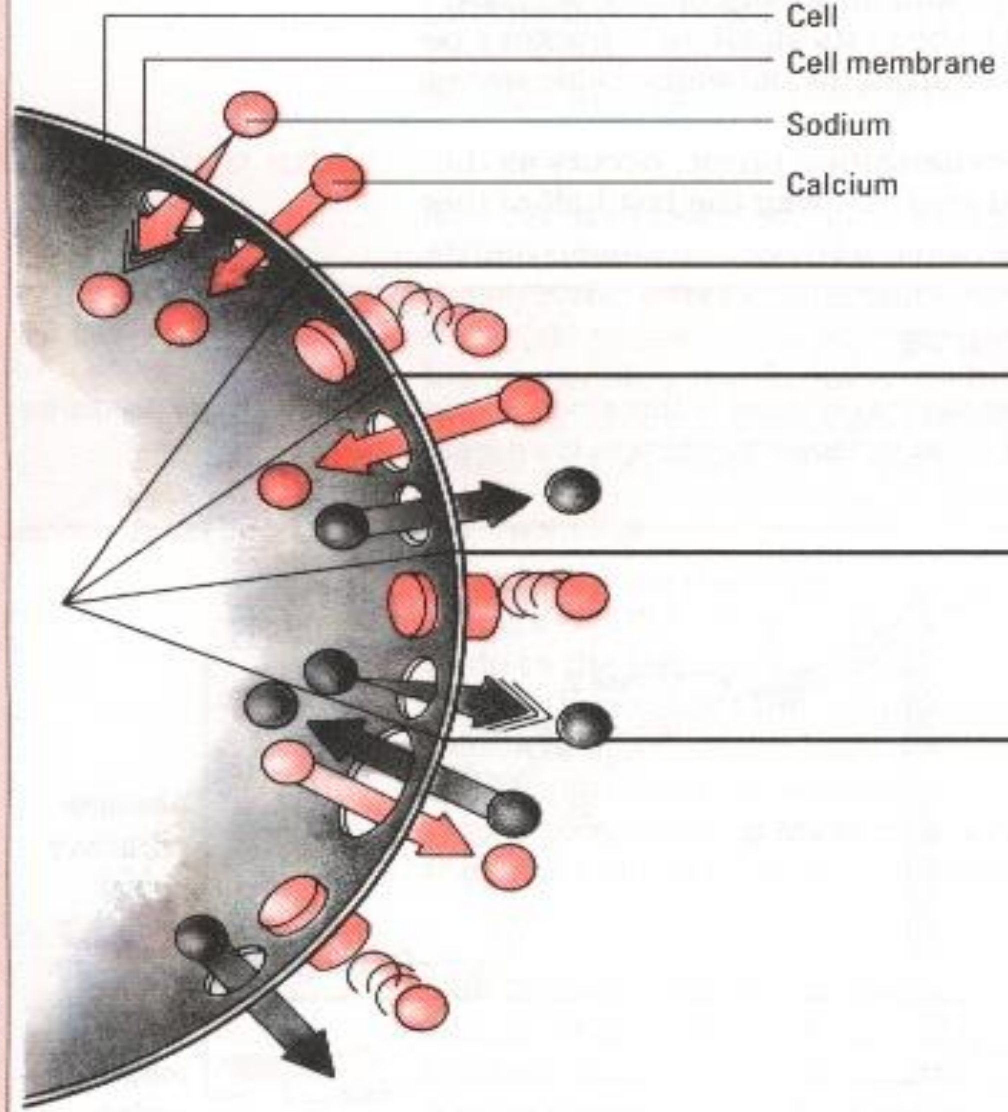
Cardiac Action Potential

- The electrical activity of an individual cardiac cell.
- The electrical impulse of the heart is the summation of thousands of tiny electrical currents generated by thousands of individual cardiac cells .

• Depolarization:	Phase O
• Repolarization:	Phases 1-3
• Resting phase:	Phase 4

Depolarization-repolarization cycle

Use this illustration to review the five phases of the depolarization-repolarization cycle.



Phase 0: Rapid depolarization
- Sodium moves rapidly into the cell.
- Calcium moves slowly into the cell.

Phase 1: Early repolarization
- Sodium channels close.

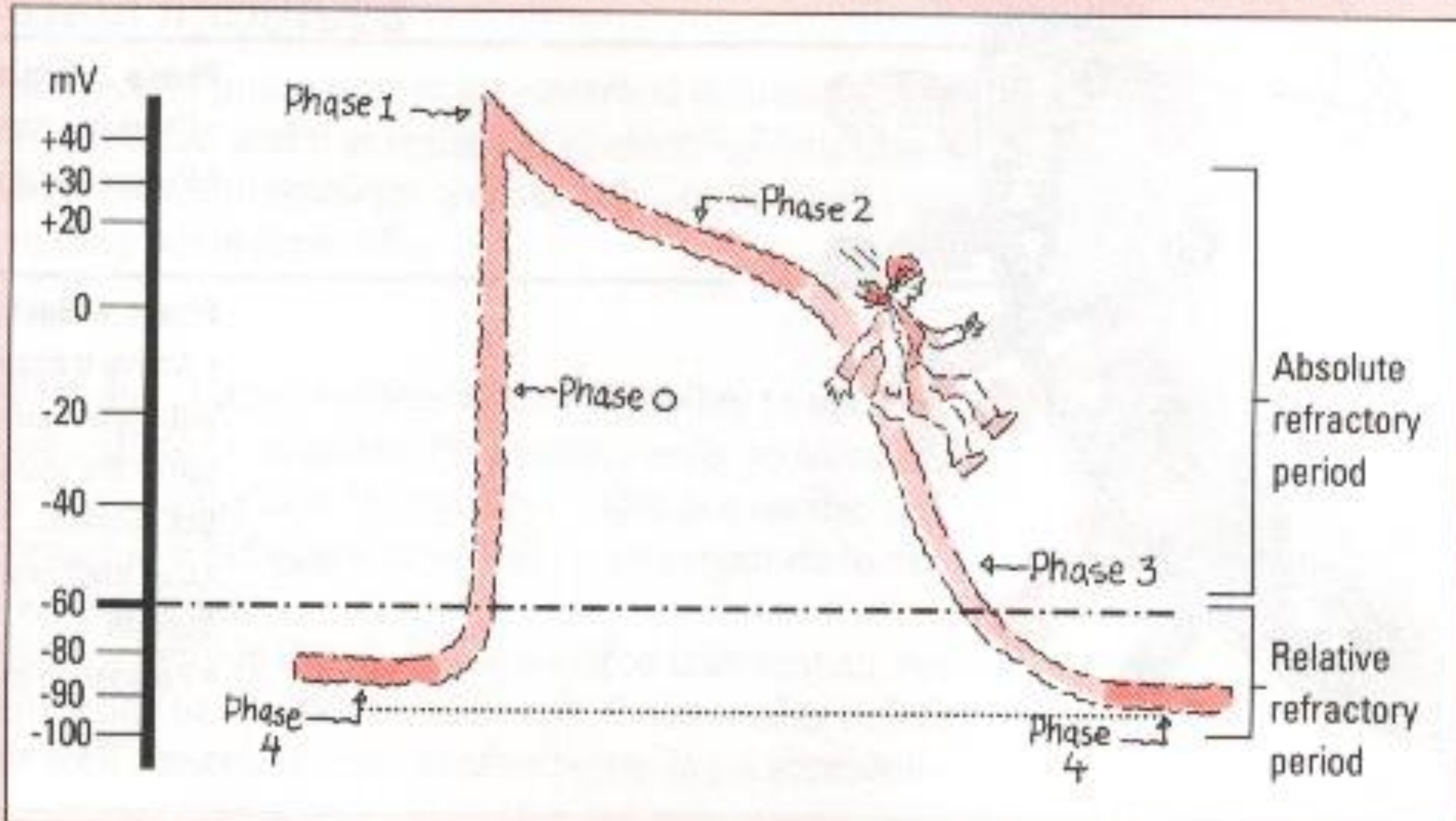
Phase 2: Plateau phase
- Calcium continues to flow in.
- Potassium flows out of the cell.

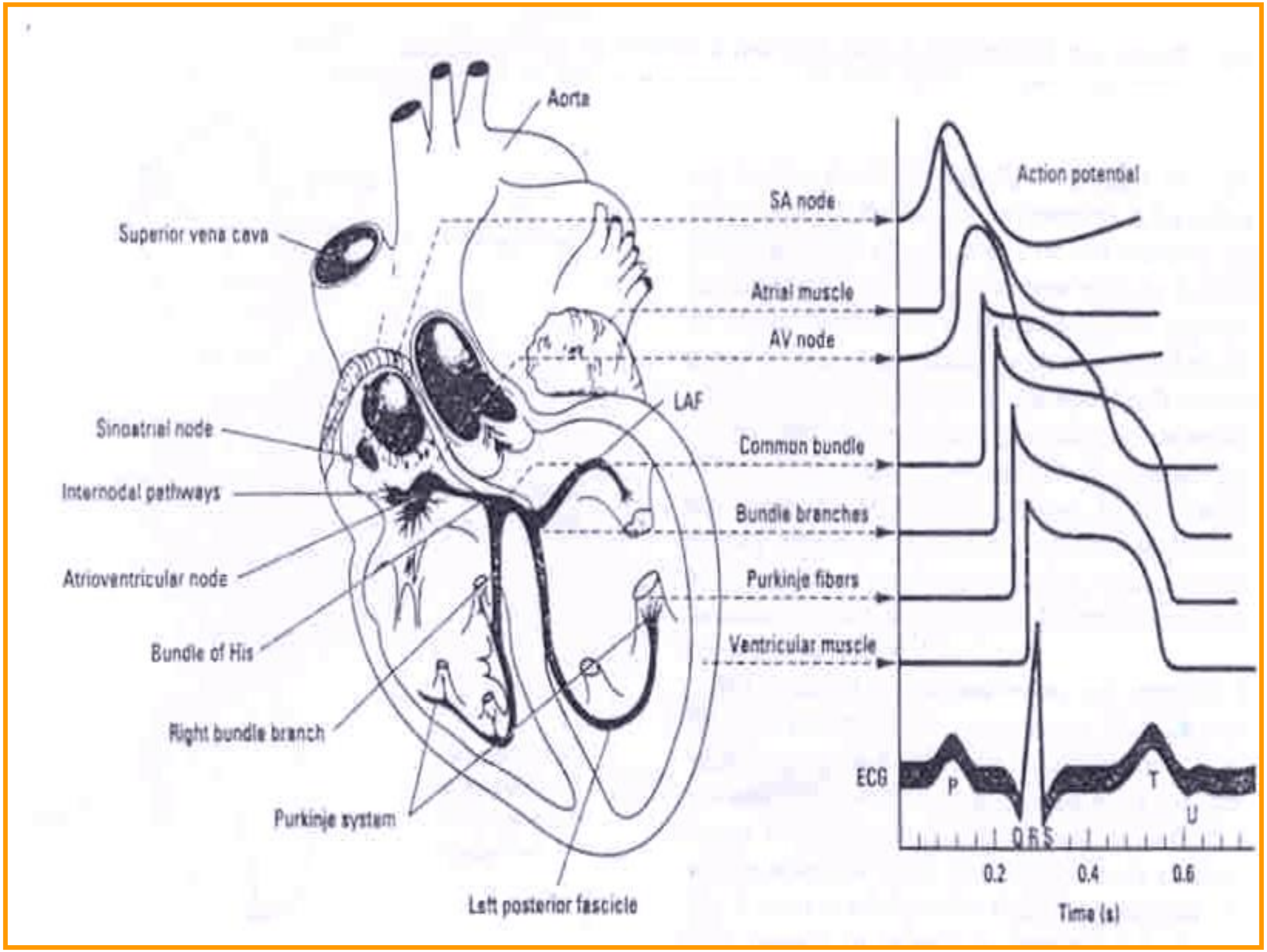
Phase 3: Rapid repolarization
- Calcium channels close.
- Potassium flows out rapidly.

Phase 4: Resting phase
- Active transport through the sodium-potassium pump begins restoring potassium to the inside of the cell and sodium to the outside.
- Cell membrane becomes impermeable to sodium.
- Potassium may move out of the cell.

Action potential curve

An action potential curve shows the electrical changes in a myocardial cell during the depolarization-repolarization cycle. This graph shows the changes in a nonpacemaker cell.




Aorta
Superior vena cava
Sinoatrial node
Internodal pathways
Atrioventricular node
Bundle of His
Right bundle branch
Purkinje system
Left posterior fascicle
LAF
SA node
Atrial muscle
AV node
Common bundle
Bundle branches
Purkinje fibers
Ventricular muscle
Action potential
ECG
P
Q R S
T
U
0.2
0.4
0.6
Time (s)

Localized Variations in the Heart's Electrical System: autonomic innervations

- Sympathetic tone:

  - Enhance automaticity (rapid firing).
  - Increase conductive velocity.
  - Decrease refractory period

- Parasympathetic tone:

  - Depress automaticity (slow firing).
  - Decrease conductive velocity.
  - Increase refractory period

Localized Variations in the Heart’s Electrical System : slow versus fast

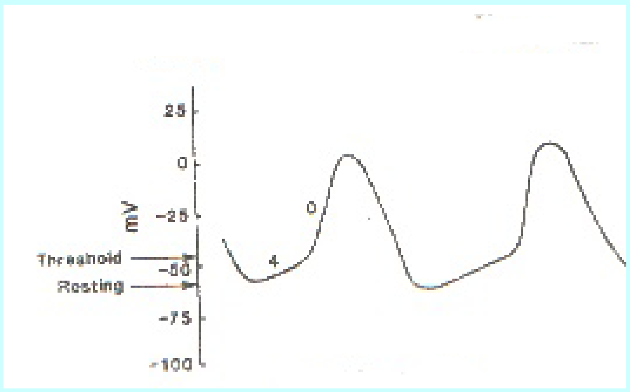
SA node

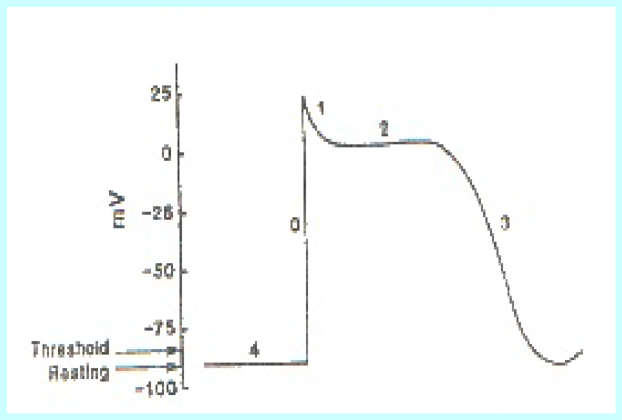
AV node

Atrial myocytes

HIS-Purkinje cells

Ventricular myocytes





Slow-Response or Calcium-Channel Action Potential

Fast-Response or Sodium-Channel Action Potential

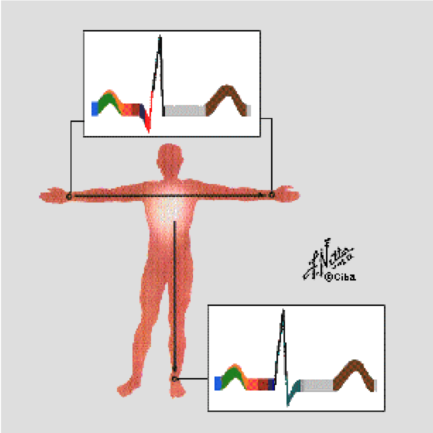
Relationship Between Action Potential and Surface ECG

- The surface ECG reflects the electrical activity of the entire heart.
- *Depolarization phase of atria and ventricles:*

  - Instantaneous and occurs sequentially from cell to cell (P and QRS) and of relatively short duration and yield directional and specific information.
- *Repolarziation phase of atria and ventricles:*

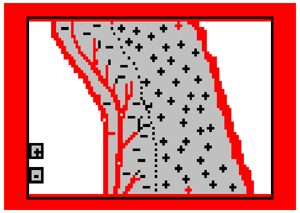
  - Not instantaneous, and occurs simultaneously (ST and T) and of relatively long duration with little directional and non specific information

Basic Principles of Electrocardiography

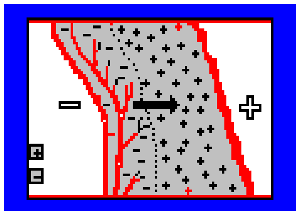


The Cellular Basis of ECG

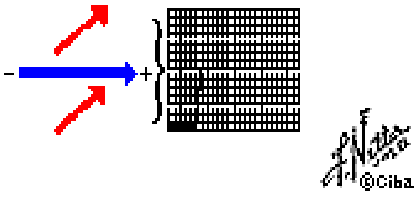
1. Electrical potentials are produced in the heart as the sum of minute amounts of electricity generated by individual cardiac muscle cells during depolarization and repolarization.



2. At any given instant, the sum of these electrical currents will have a particular direction and magnitude. The sum of these currents forms the resultant vector that produces the deflection in the electrocardiograph stylus.



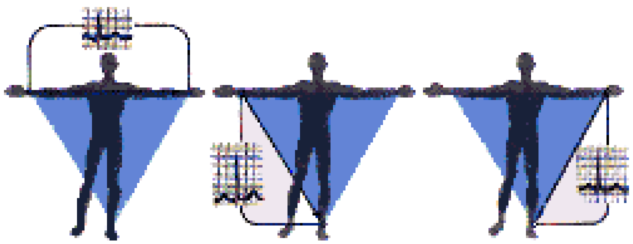
3. The relative strength of deflection is dependent on the magnitude and the angle the vector forms with the ECG lead. Thus, different leads will pick up different components of the resultant vector depending on their orientation.



The cellular basis of ECG

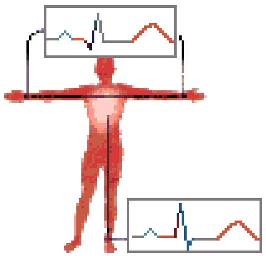
4.

Lead placement and their axes: because of their placement, each of the ECG leads "sees" the ECG signal from a different angle.



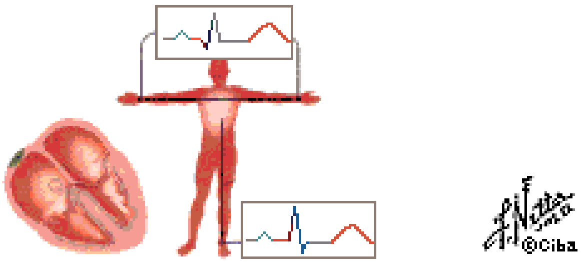
5.

Seeing the development of ECG traces as the wave of depolarization traverses the heart.



6.

The normal sequence of depolarization and repolarization and corresponding vector axes.



Current Path in the cardiac muscle

Endocardium:

The endocardium is the first part of the ventricular wall to receive the stimulation from the Purkinje system.

Purkinje Fibers:

The Purkinje fibers innervate the myocar- dial muscle fibers and thus relay the action potential from the bundle branches to the myocardium. This begins a uniform spread of muscle activation (depolariza- tion) through the muscle wall

Exterior:

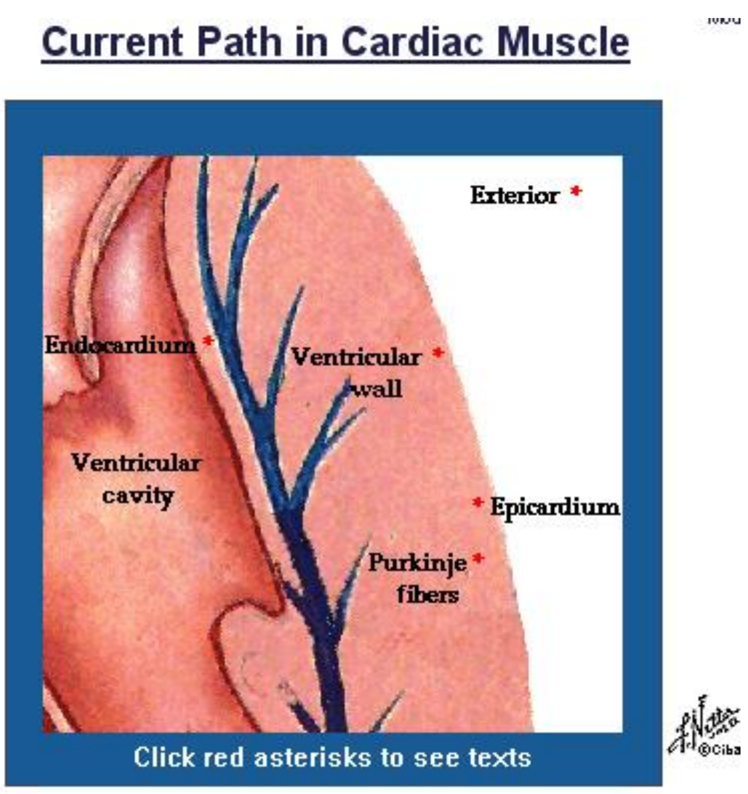
The generated potential difference is propagated to the surface of the body through the tissues in contact with the heart.

Ventricular Wall:

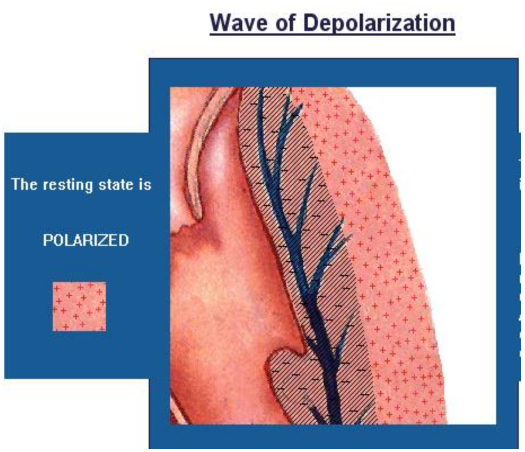
The wave of depolarization moving through the muscle wall results in a potential difference between the positively charged region and the negatively charged region.

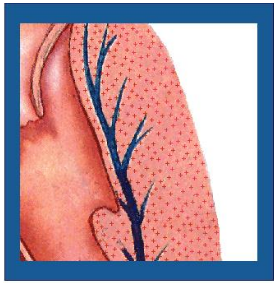
Epicardium:

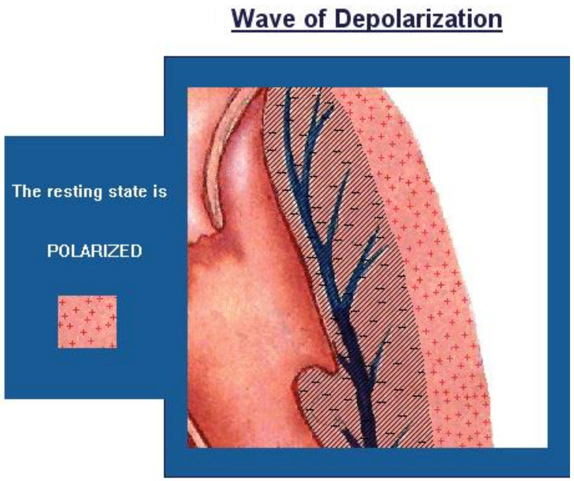
The epicardium is the last part of the ventricular wall to receive the depolarization stimulus.

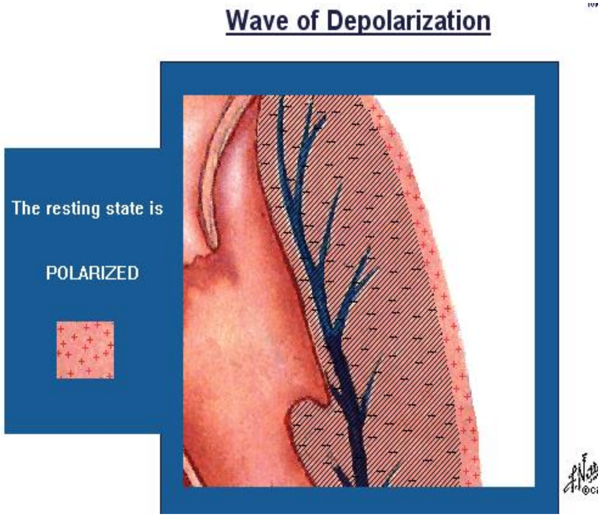


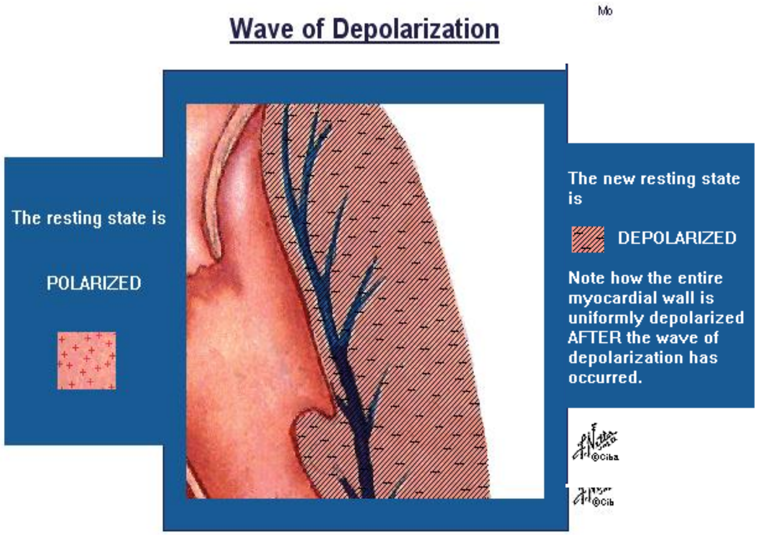
The cellular basis of ECG



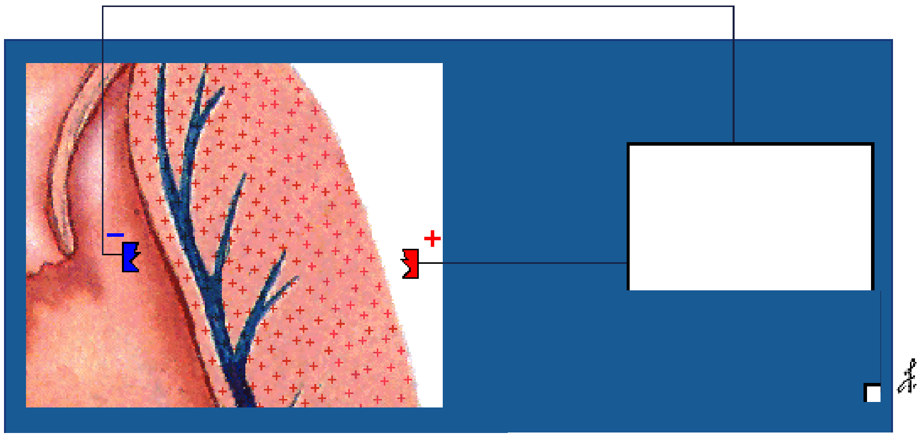


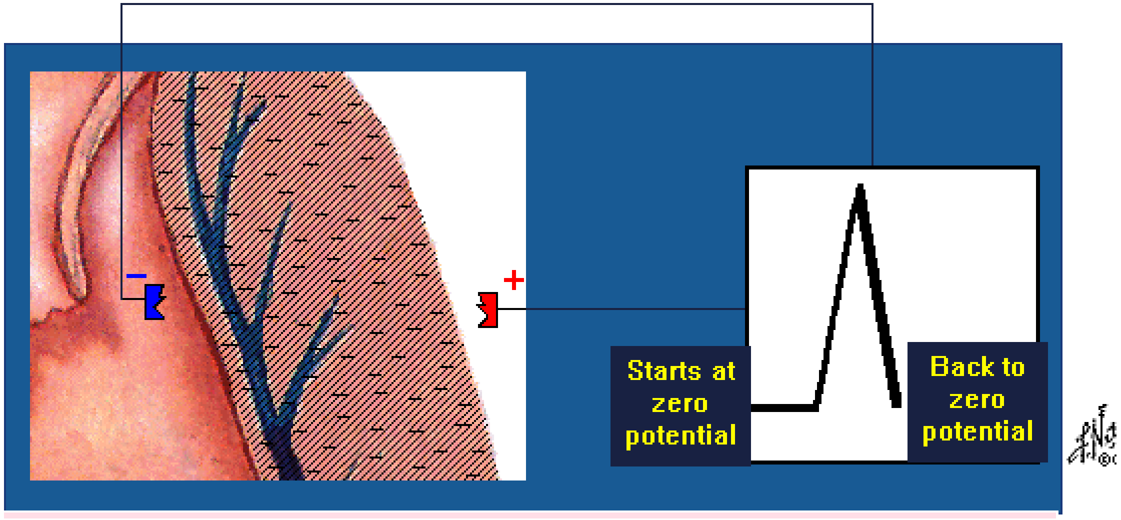




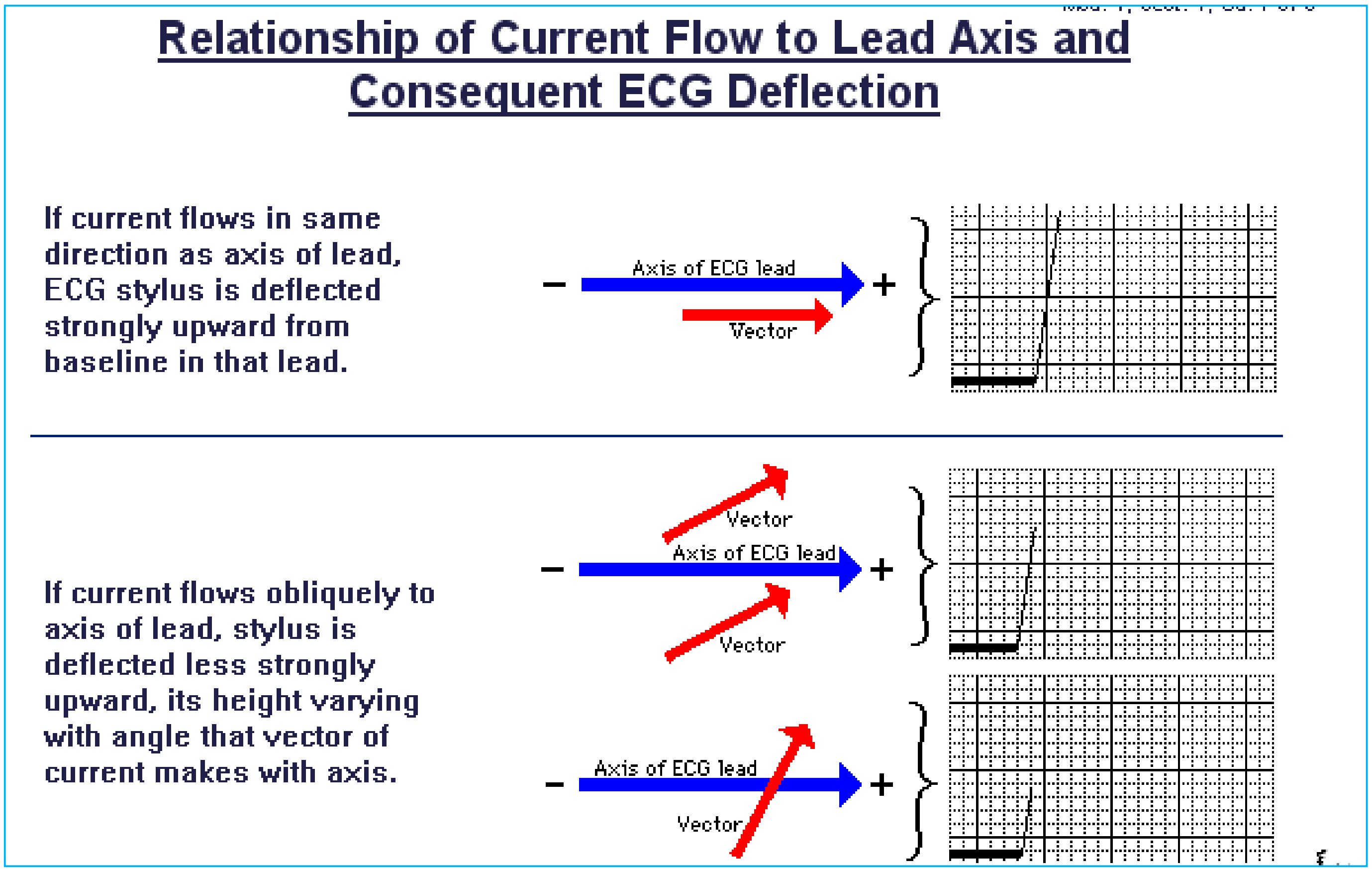


The wave of depolarization toward the positive electrode :positive deflection

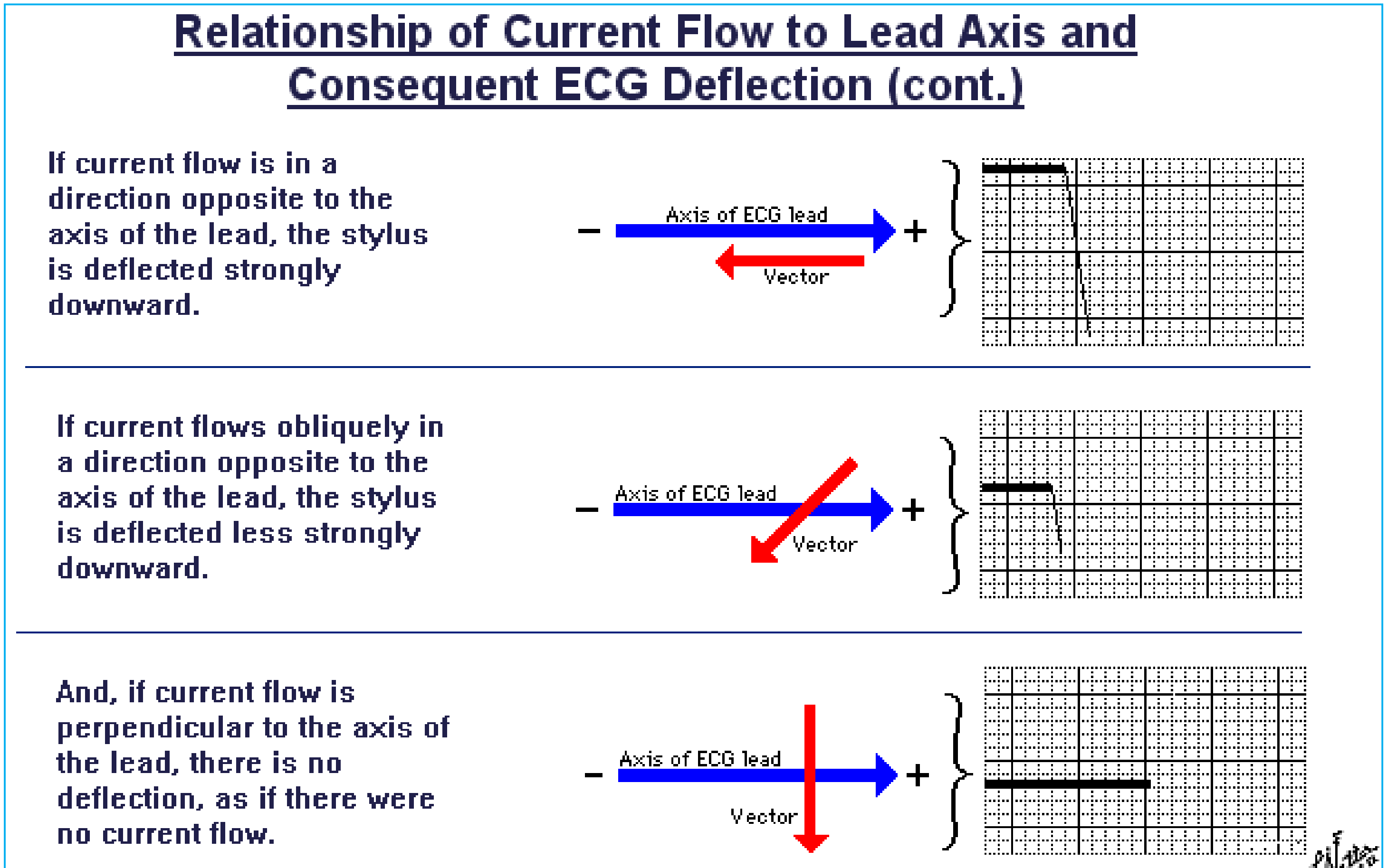




The cellular basis of ECG



The cellular basis of ECG



Basic Steps for ECG Recording

1. Confirm the identity and age of the patient requiring an ECG.
2. Explain the procedure to the patient.
3. Offer the patient privacy.
4. Remove the patient's clothing to allow ECG recording while minimizing exposure and maintaining warmth.
5. Position the patient in the supine position if possible. Patients with severe respiratory compromise will not be able to lie in this position and may need to have an ECG performed while sitting or semi-recumbent.
6. Place the ECG electrodes in the correct position on the patient's chest and limbs. This may require drying of the skin.
7. Connect the labelled ECG leads to their corresponding electrodes.

Basic Steps for ECG Recording

8. Turn on the ECG machine.
9. Press the ‘filter’ switch to ‘on’.
10. Enter patient details including medication.
11. Advise the patient to relax and lie still.
12. Press the appropriate button on the machine to initiate recording, usually ‘start’ or ‘auto’.
13. Review the printed ECG to confirm adequacy of the tracing and to identify the immediate life-threatening abnormalities .
14. If the ECG machine does not allow direct entry of patient details, these should be *attached* to the ECG as soon as the tracing is recorded.

ECG Recording:

- The modern, standard 12-lead ECG requires that 10 ECG leads be attached to the patient's body. The leads are labelled to assist correct placement. These leads must be placed correctly to avoid obtaining a misleading ECG.
- The ECG leads should be placed as follows :

1. LL: left leg, distally
2. RL: right leg, distally
3. LA: left arm, distally
4. RA: right arm, distally
5. V1: fourth intercostal space, to the right of the sternum
6. V2: fourth intercostal space, to the left of the sternum
7. V3: midway between V2 and V4
8. V4: fifth left intercostal space, mid-clavicular line
9. V5: at the horizontal level of V4, anterior axillary line .
10. V6: at the horizontal level of V4 and V5, mid-axillary line.

Accurate positioning of precordial leads

- Accurately locating the fourth intercostal space is important. One of the most common errors in recording an ECG is to place V1 and V2 too high, resulting in all V leads positioned at a higher level on the chest.
- The fourth intercostal space is found by undertaking these steps:
- 1. Identify the sternal angle or ‘angle of Louis’ (the angle between the upper part of the sternum and the body of the sternum), where the manubrium meets the body of the sternum. Run your finger down the sternum from the sternal notch at the top, until you meet a bony horizontal ridge. This is the sternal angle.
- 2. From this ridge, slide your finger down and to the side to locate the second intercostal space.
- 3. Count down from this space to identify the third and fourth intercostal spaces.
- 4- When recording an ECG from female patients, the convention is to place the lateral chest leads (V4, 5 and 6) beneath the breast, rather than over it.

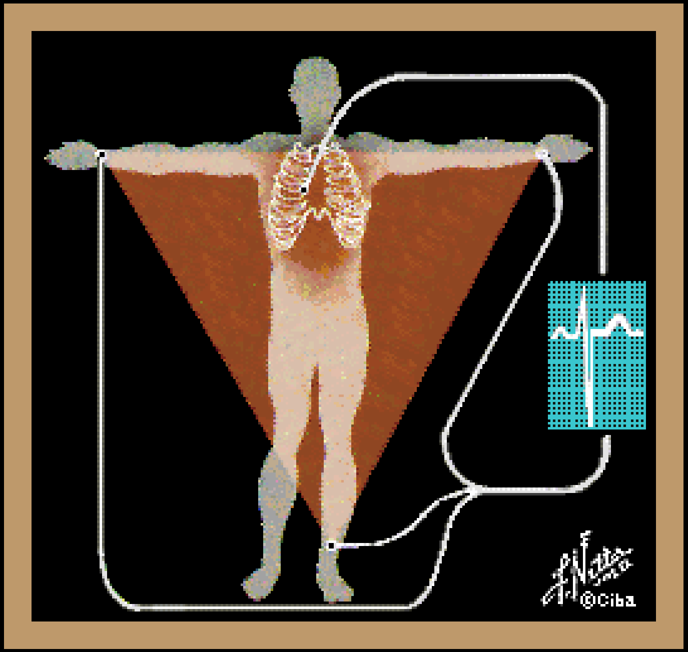
Normal ECG

- A standard 12-lead ECG records these PQRST complexes in real time from different locations around the heart. Hence, every lead appears slightly different, while still containing a PQRST complex.
- Of the 12 leads, six are referred to as ‘limb leads’. The limb leads are leads I, II, III, aVR, aVL and aVF. The other six are referred to as ‘chest’ or ‘precordial’ leads. These leads are V1, V2, V3, V4, V5 and V6.
- The limb leads record the electrical activity in the heart in the vertical /coronal plane.
- The chest leads record the electrical activity of the heart in the horizontal/ axial plane. Thus, different leads can be grouped together when looking for consistency of ECG appearances (normal or abnormal) for different parts of the heart.

The ECG Lead placement

Since the human body is made up of tissues containing electrolytic fluids, the potential difference generated in the heart is conducted to the surface of the skin. Thus, leads placed in conventional locations on the surface of the body are sufficient to record the electrical activity occurring within the heart.

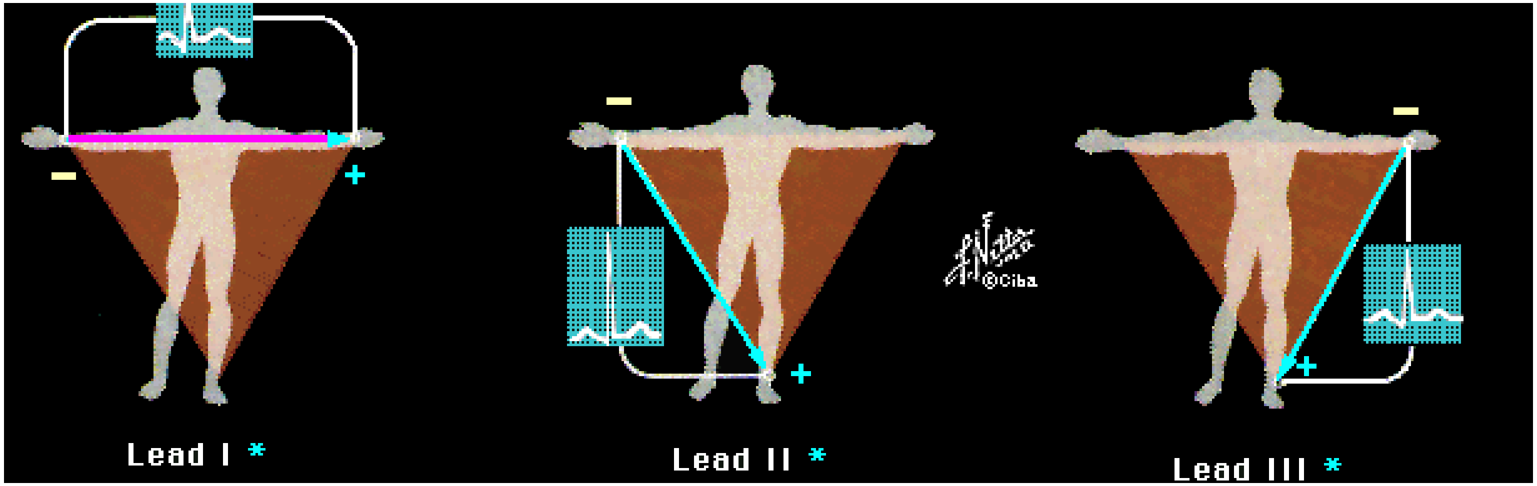
The electrocardiogram is a graphic representation of the electrical activity of the heart. This electrical activity is recorded from 12 different viewpoints by placing "leads" on the arms, legs, and chest.



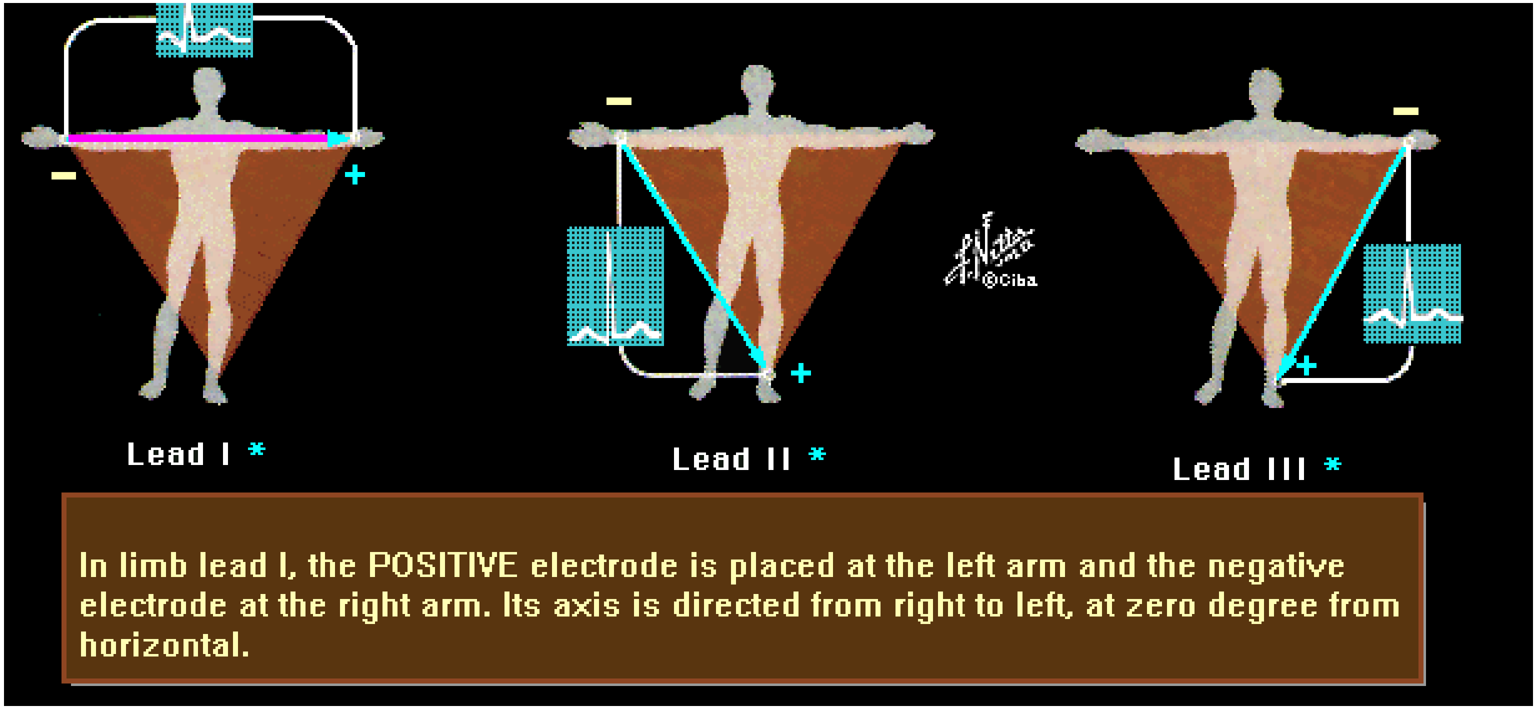
The following screens illustrate where these leads are placed to record the three bipolar limb leads, the three augmented (unipolar) limb leads, and the six chest leads.

Bipolar Limb leads and their axes

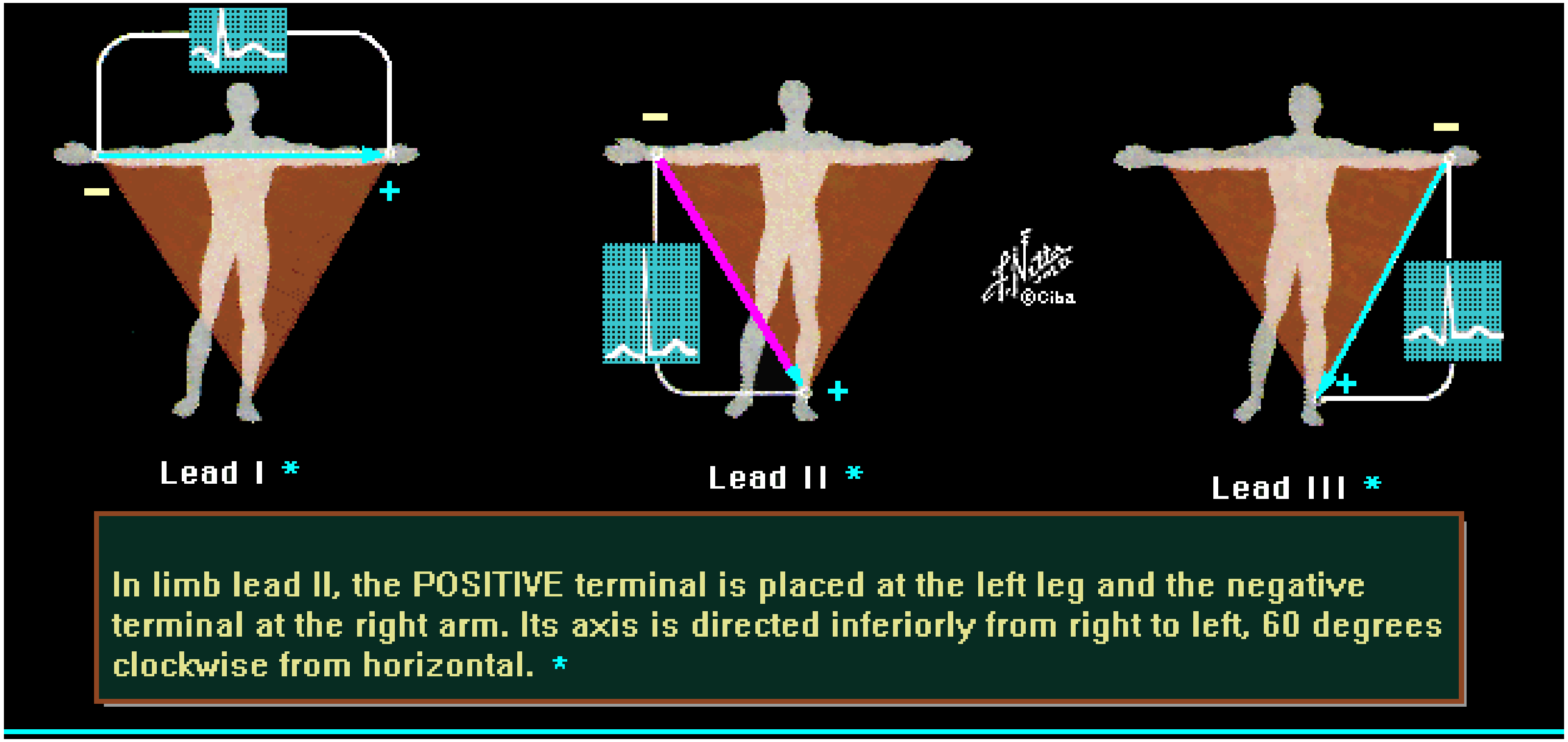
These leads use two electrodes a positive + and a – negative to record the electrical potential difference in the frontal plane



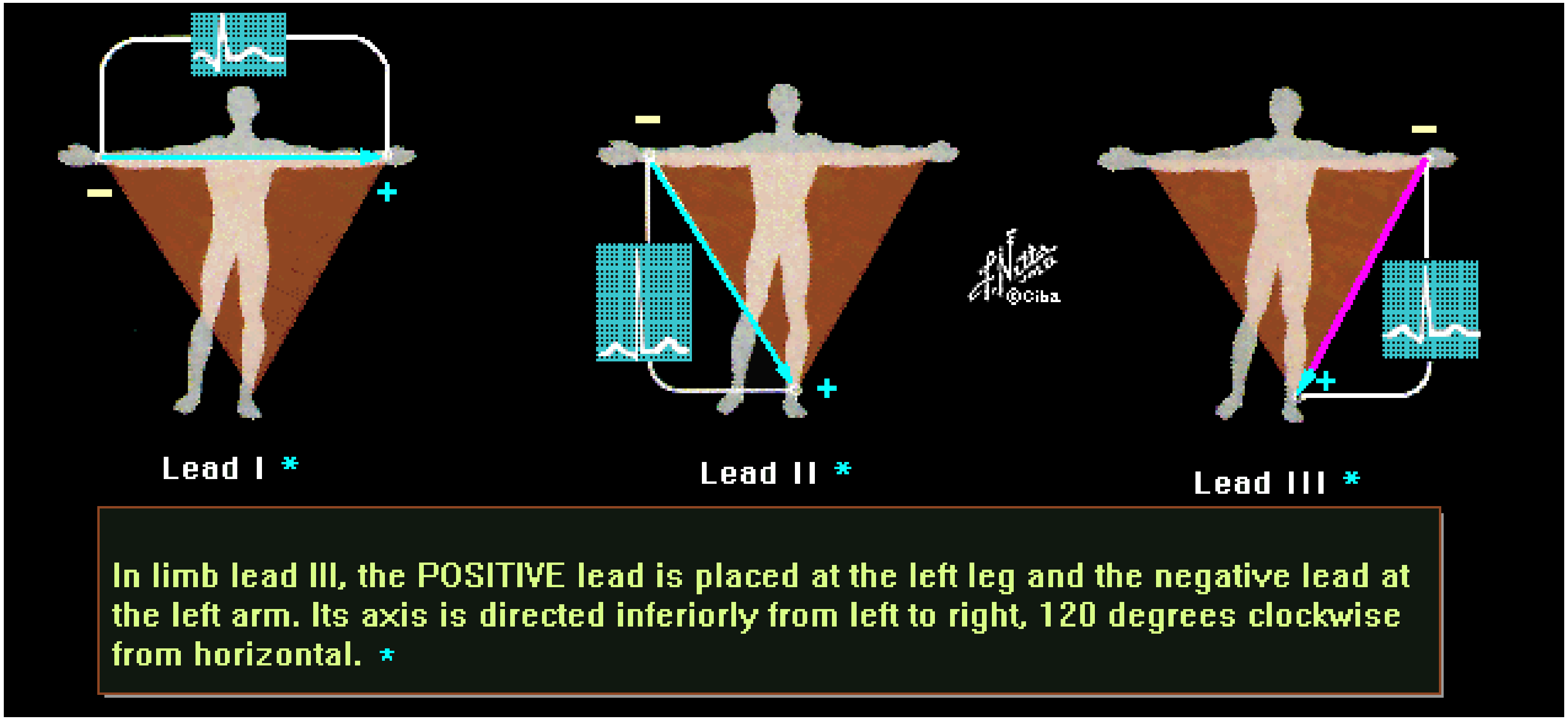
Bipolar Limb leads :Lead I



Bipolar Limb leads :Lead II

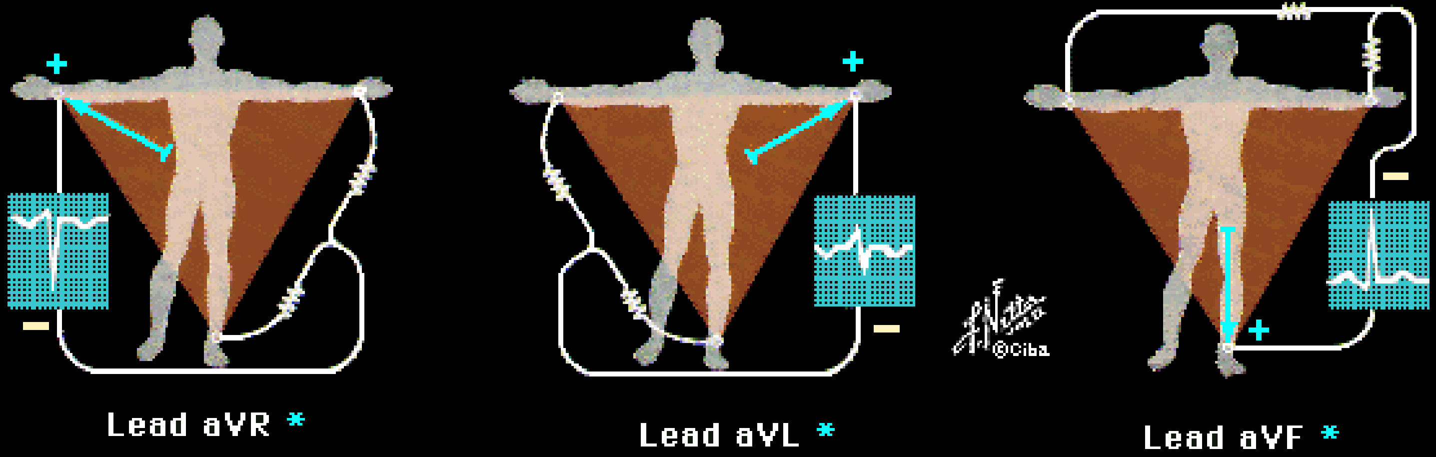


Bipolar Limb leads :Lead III



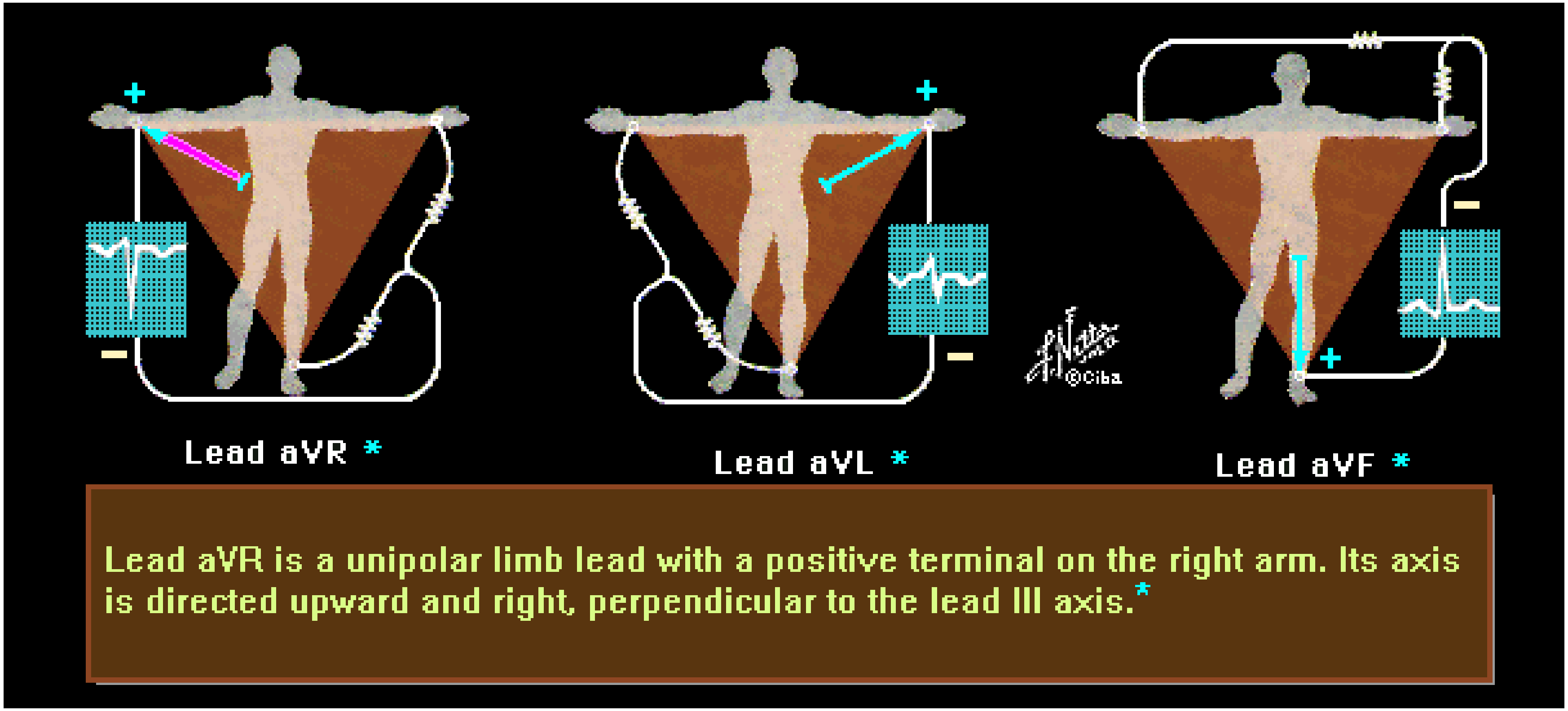
Augmented unipolar limb leads and their axes

The leads shown below are called the augmented limb leads, which also record the electrical potential in the frontal plane. They are called unipolar leads, however, because the center of the heart is used as a reference point and the electrode (positive +) is placed on the limbs and used as the other point.

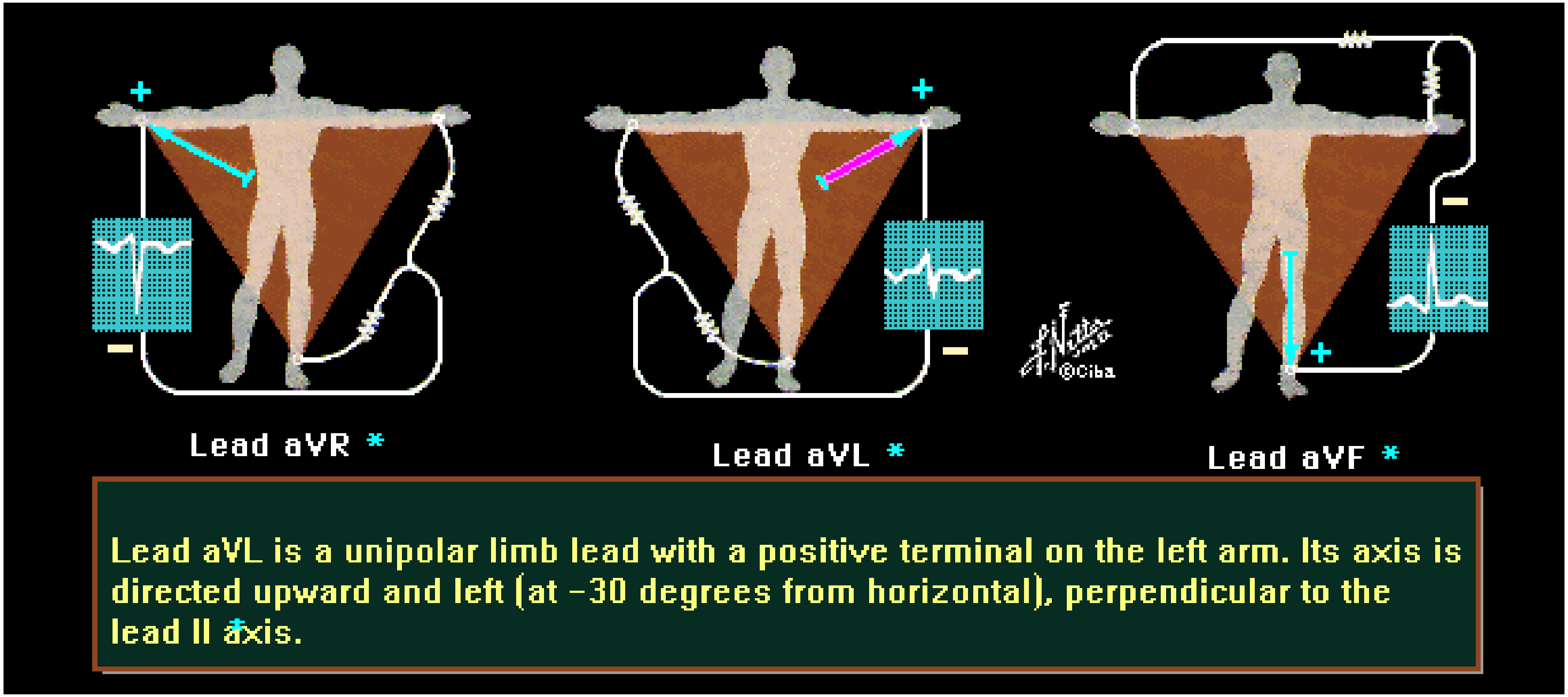


In the augmented limb leads, one limb electrode is used for the positive electrode and the other two are joined to form a ground reference.

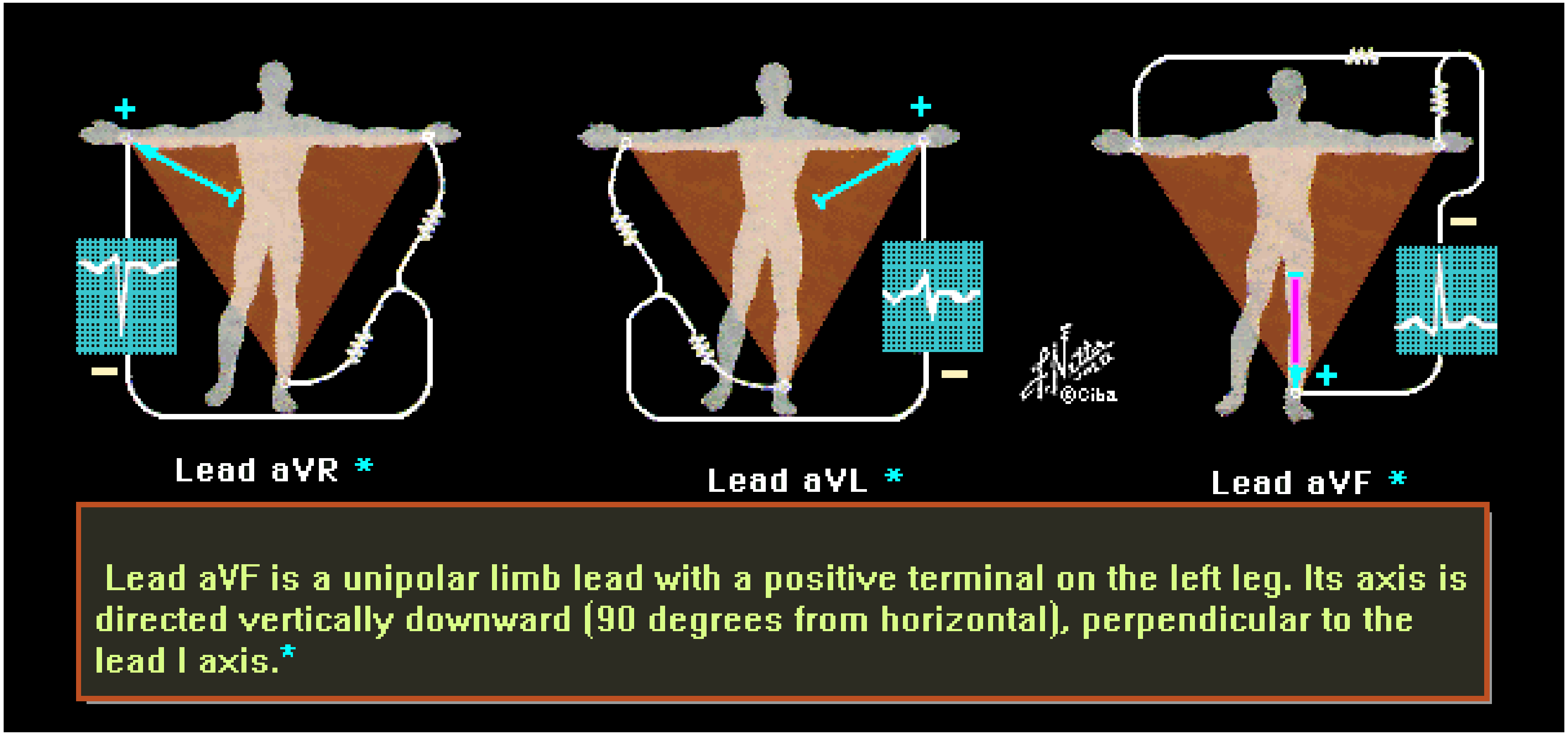
Augmented unipolar limb leads :aVR



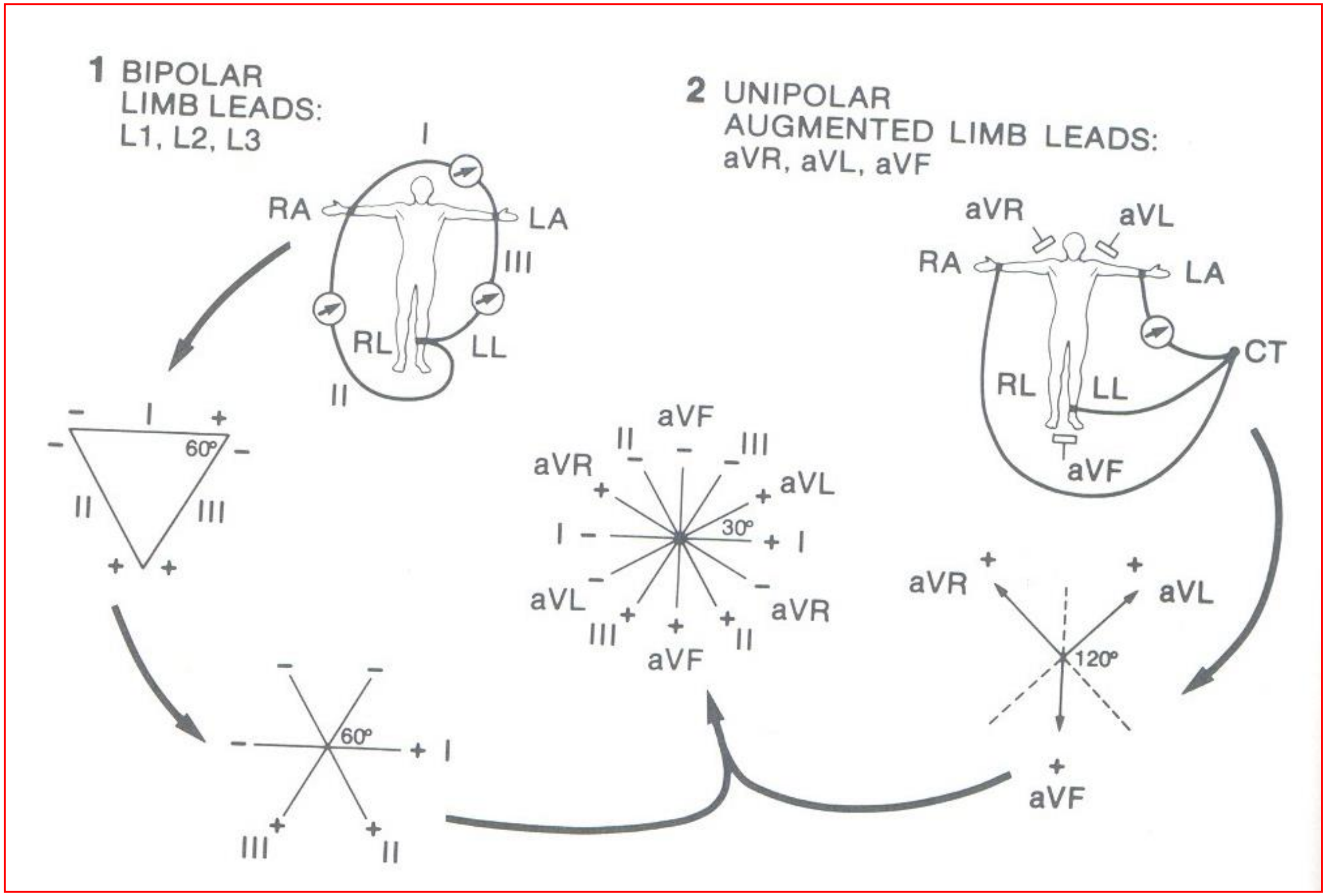
Augmented unipolar limb leads :aVL



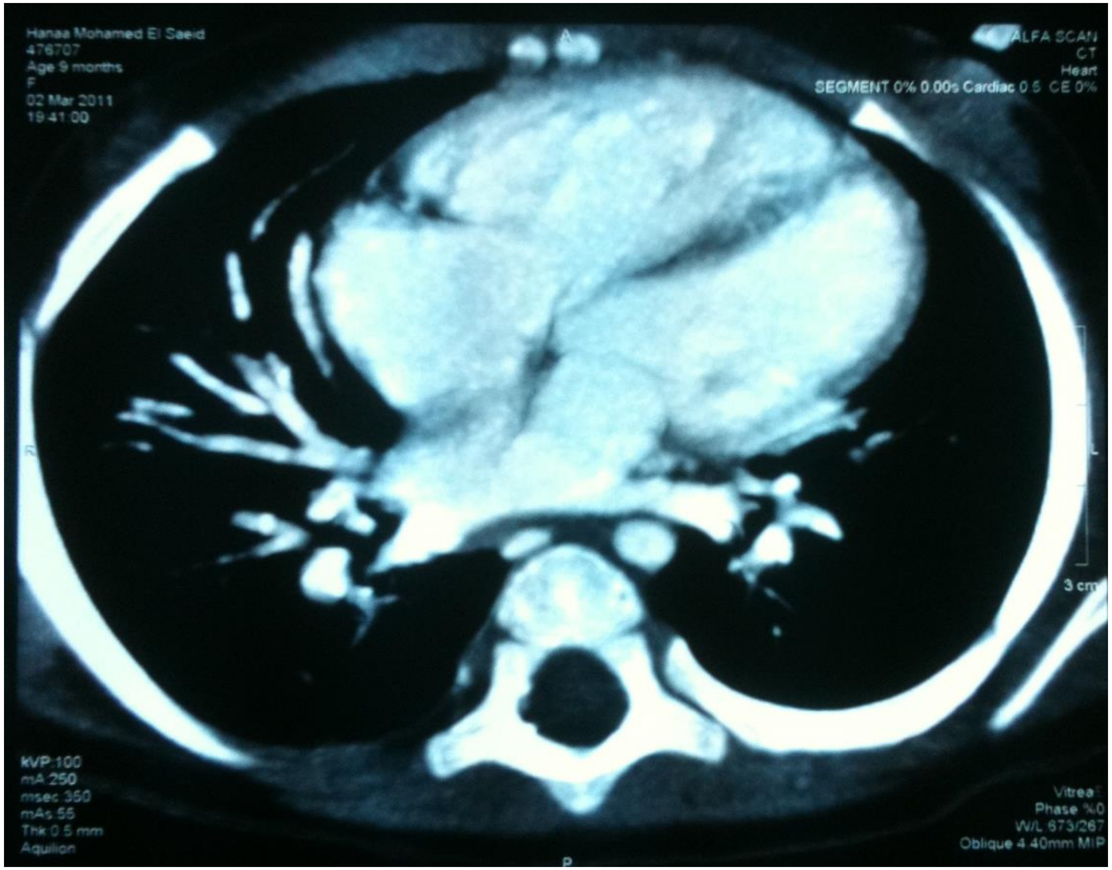
Augmented unipolar limb leads :aVF



The six Limb leads

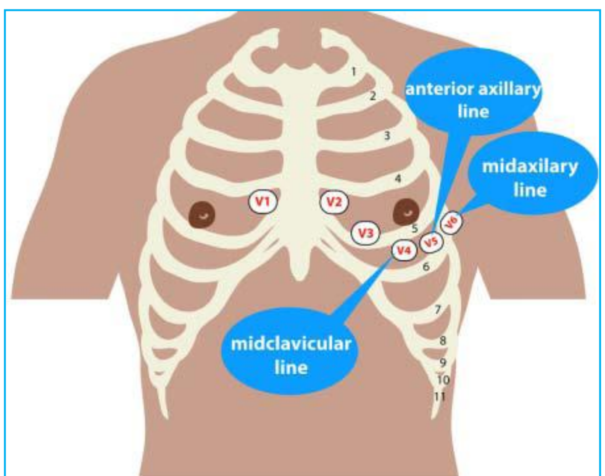


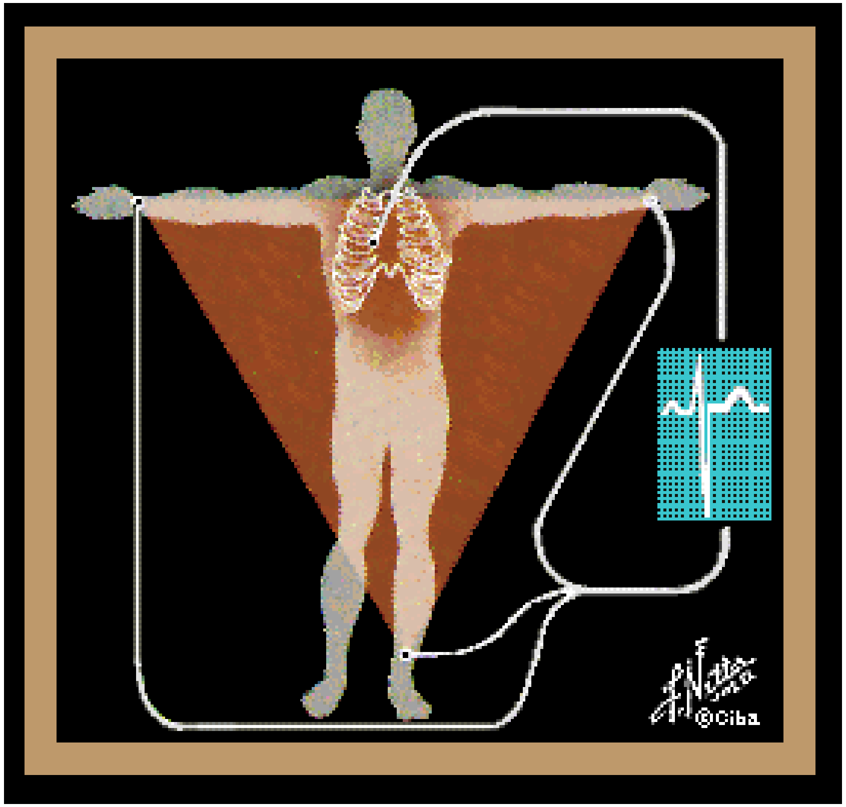
The heart within the thoracic cage



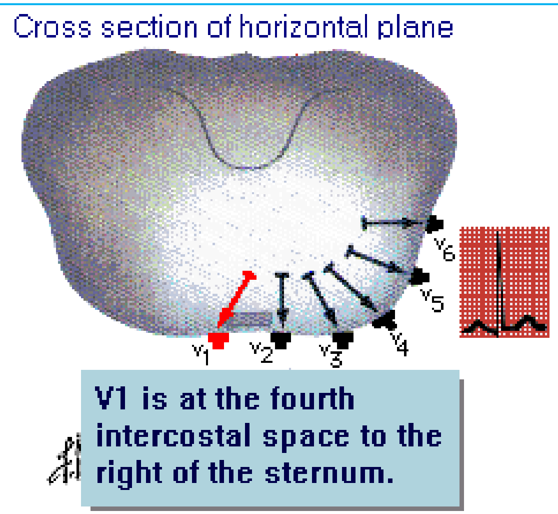
Precordial leads :V1-V6

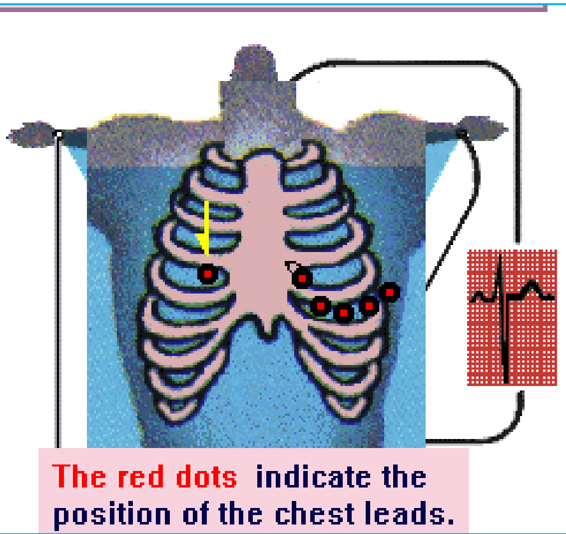
The positive electrode is placed on the chest wall and the negative pole is attached to the three limb leads



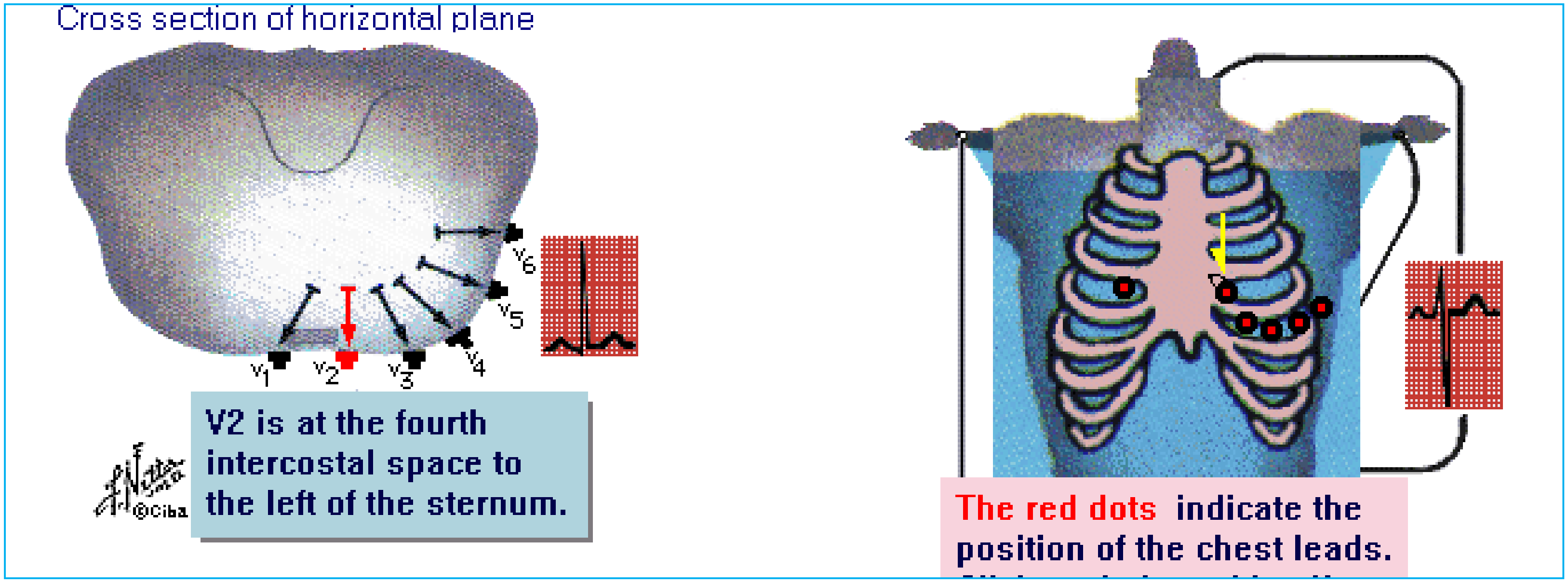


Precordial leads :V1

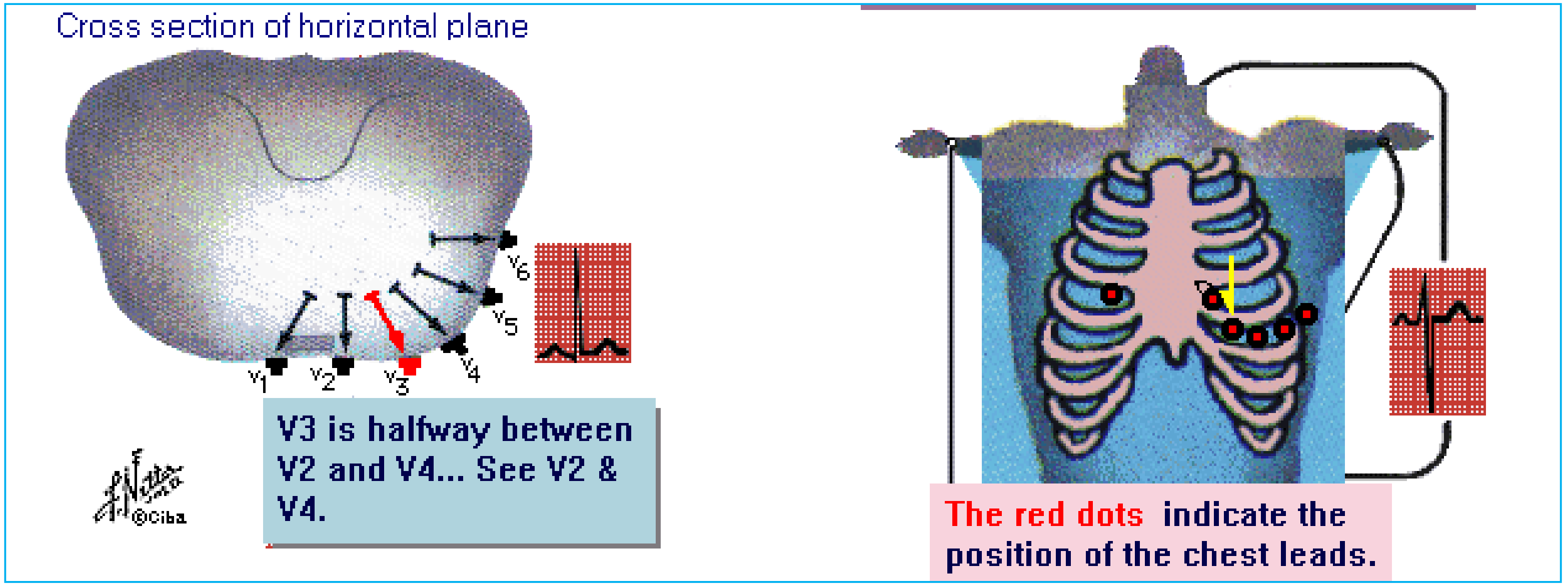




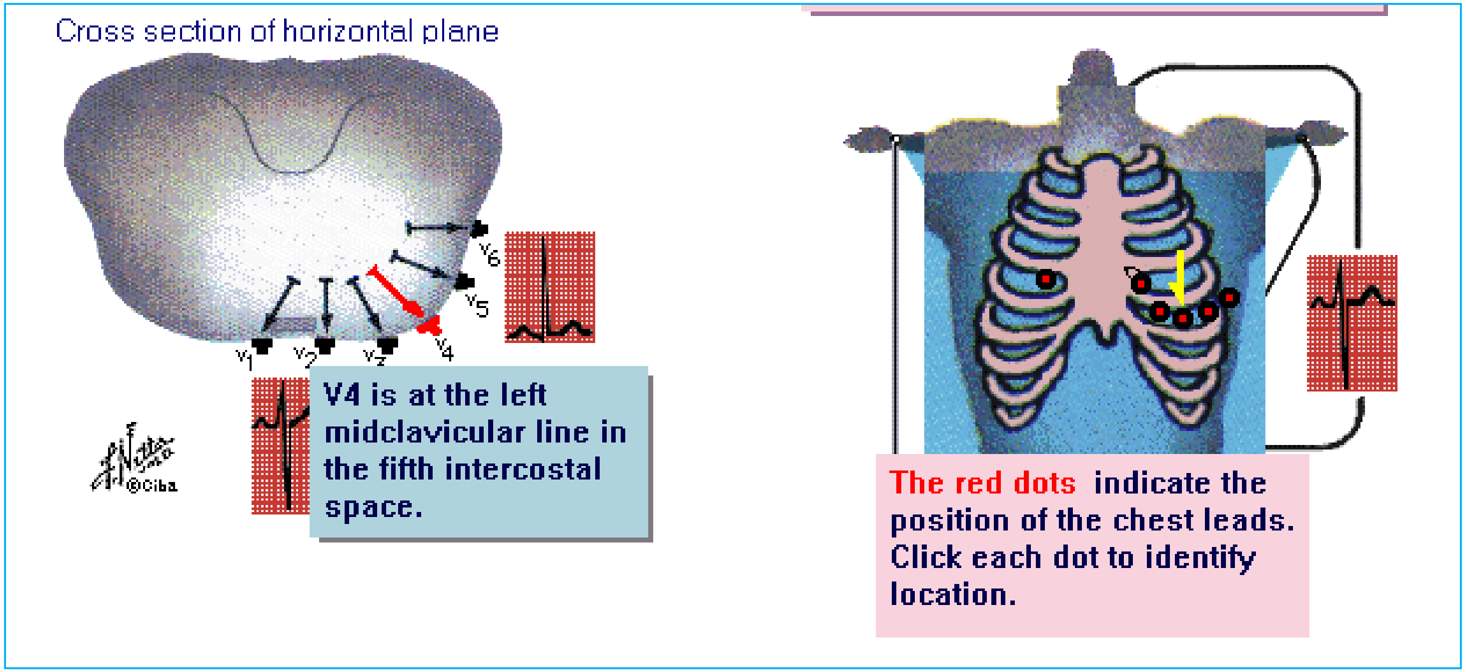
Precordial leads :V2



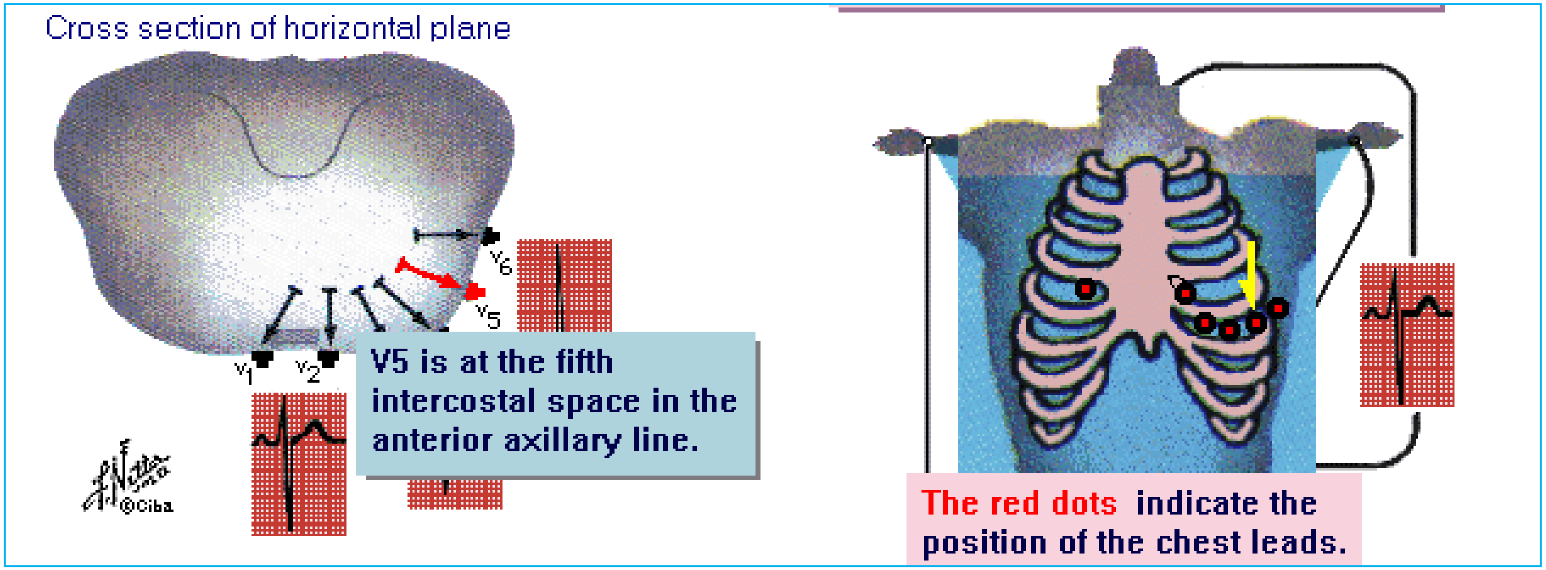
Precordial leads :V3



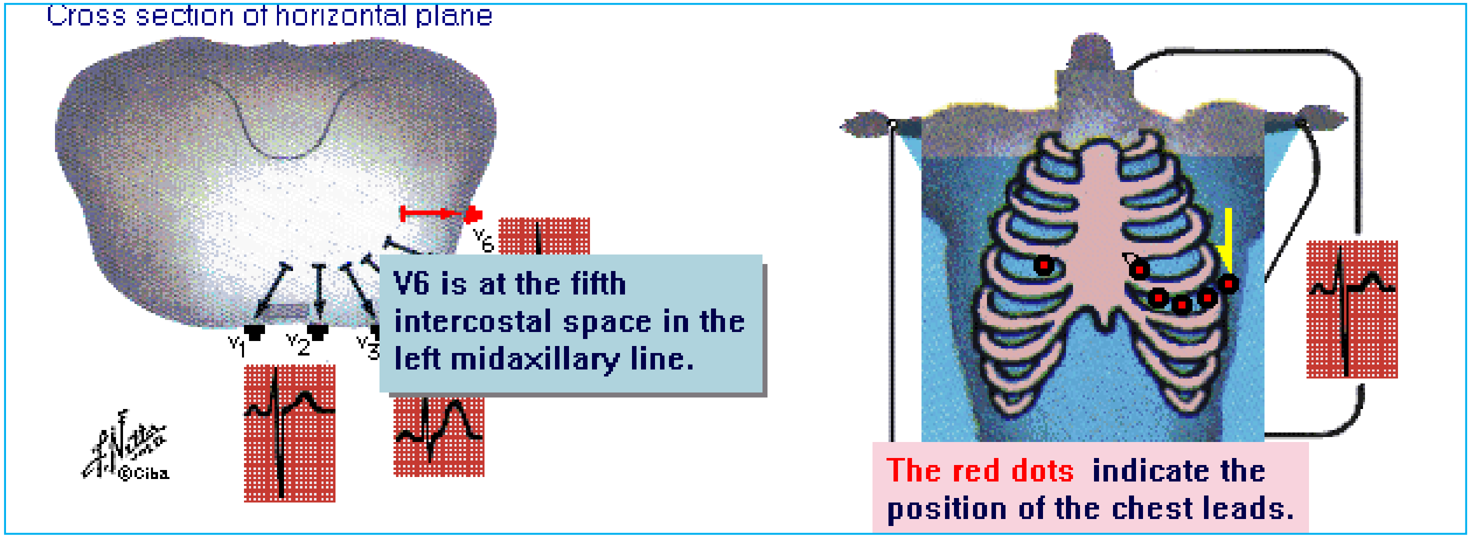
Precordial leads :V4



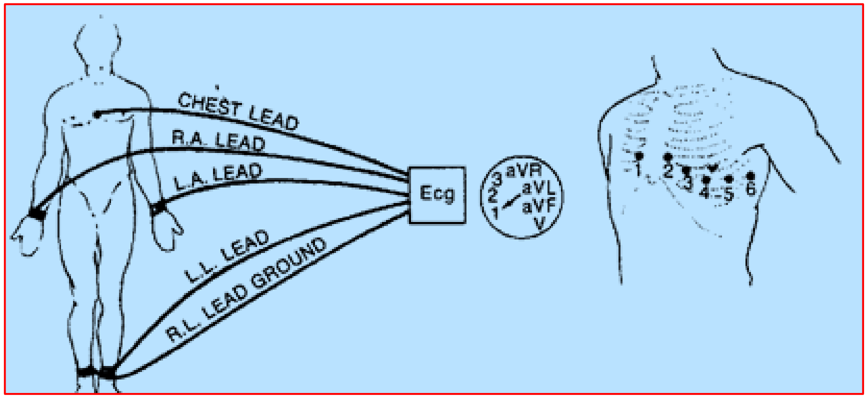
Precordial leads :V5

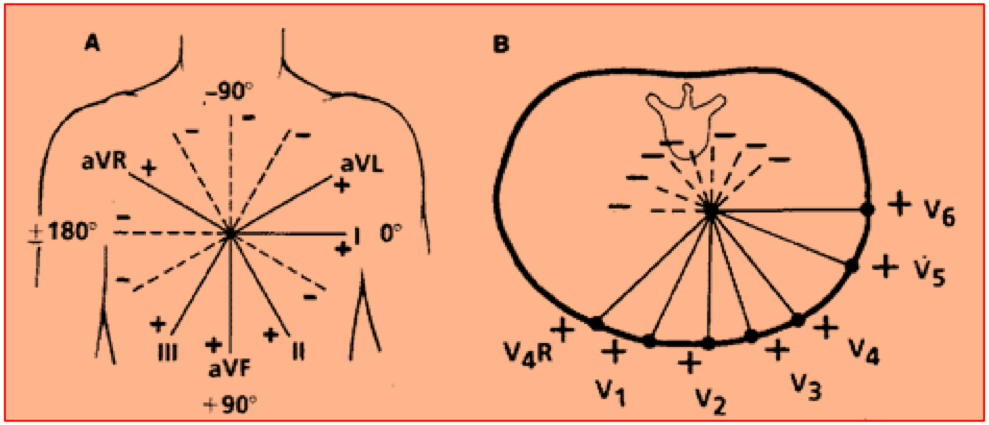


Precordial leads :V6

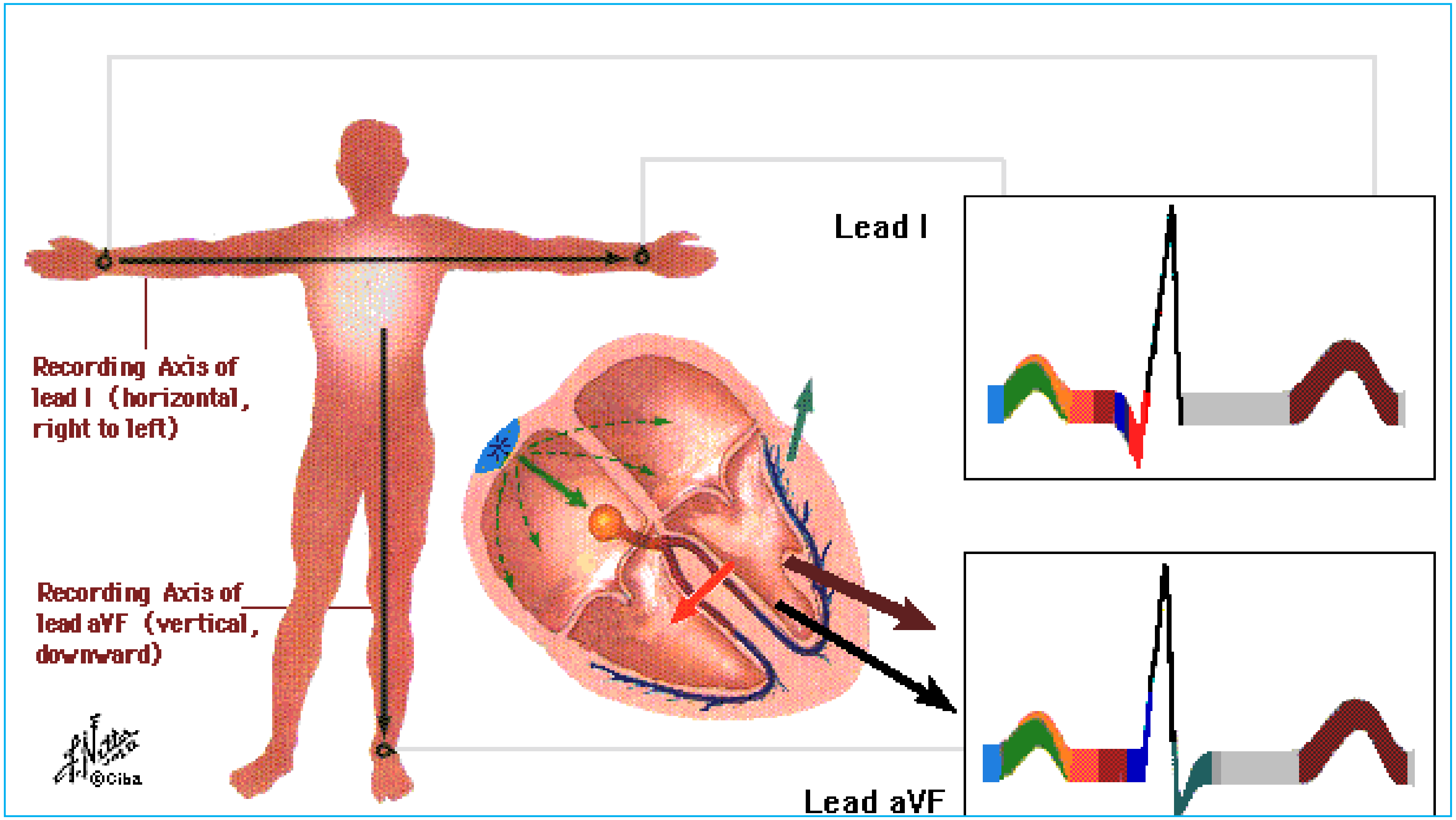


Hexa-axial Reference systems

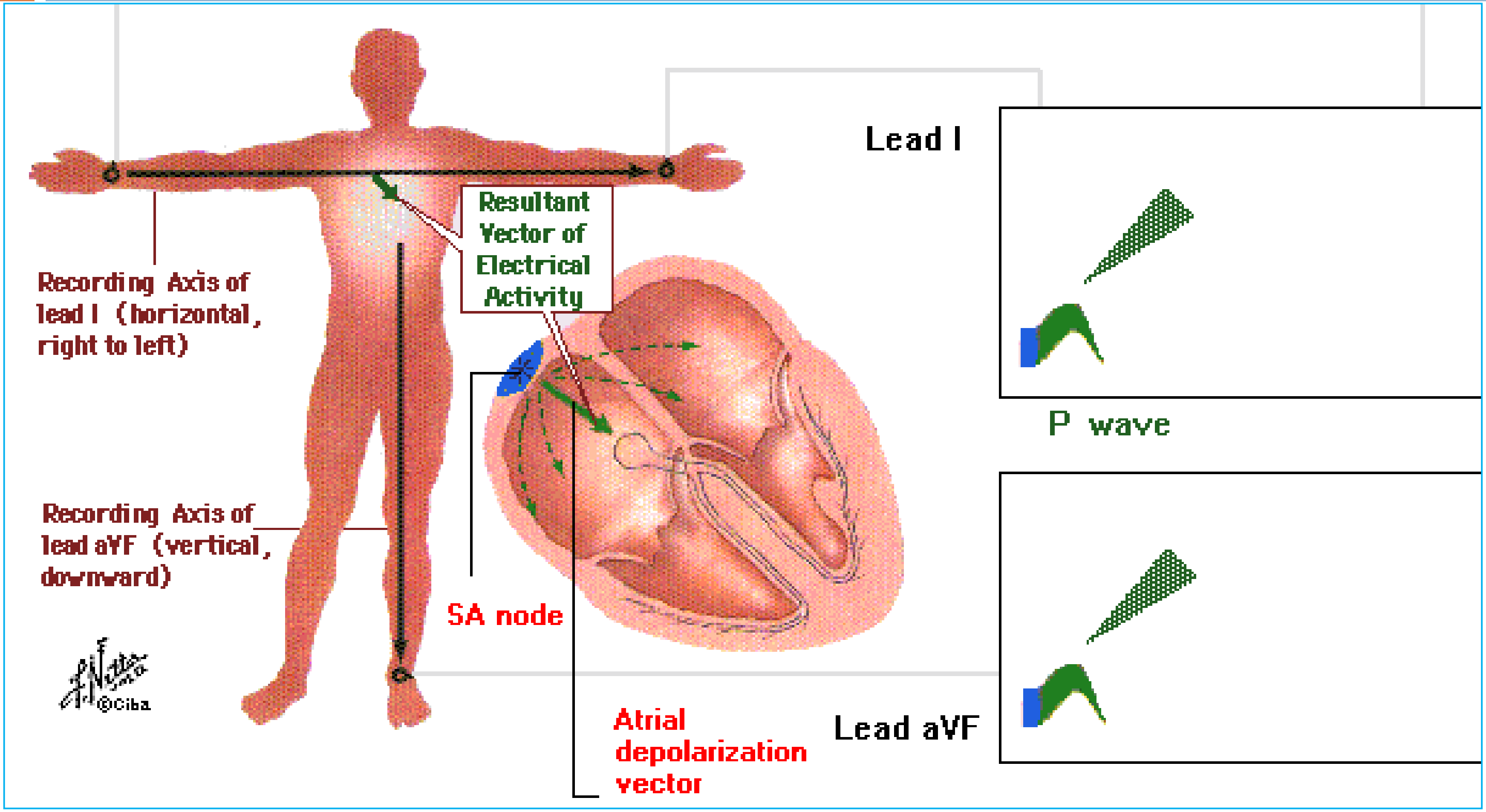




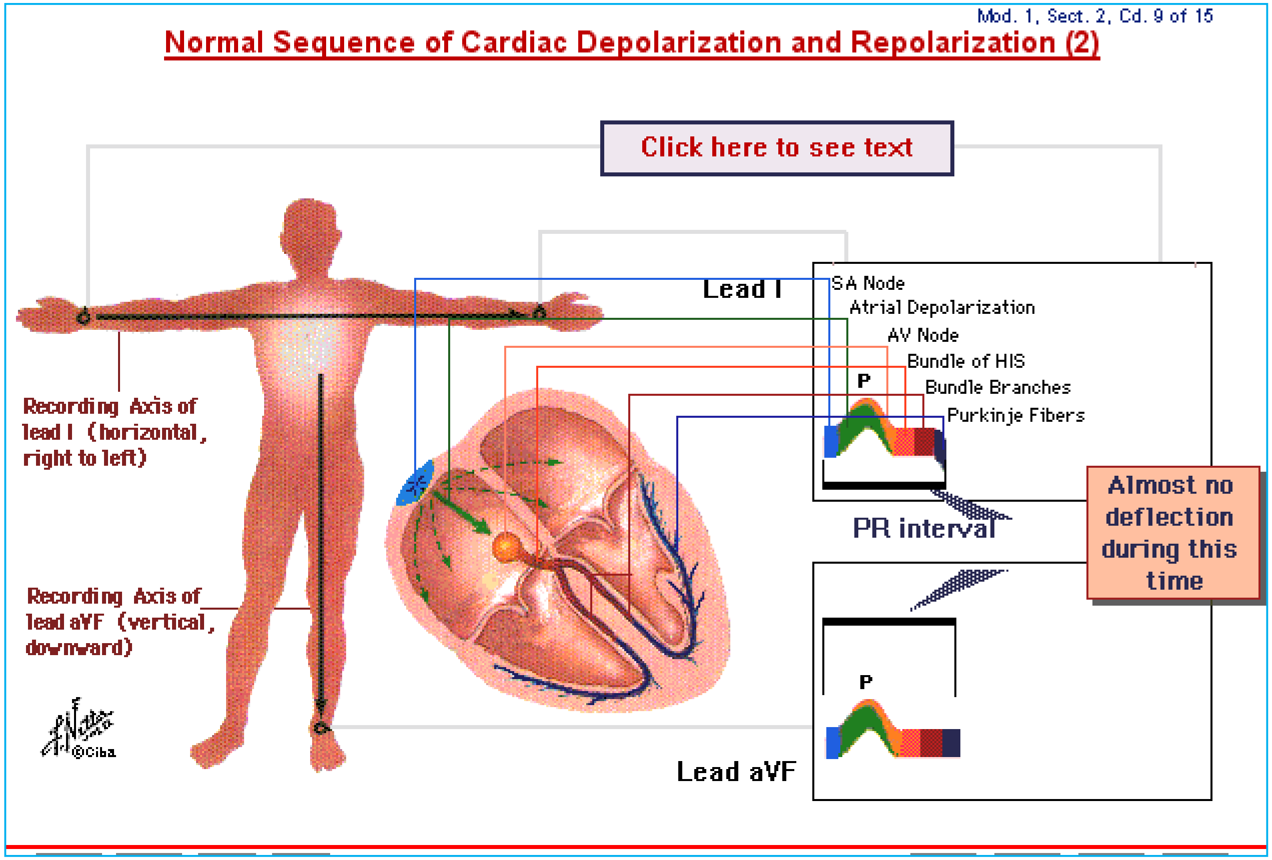
The genesis of the PQRST/U



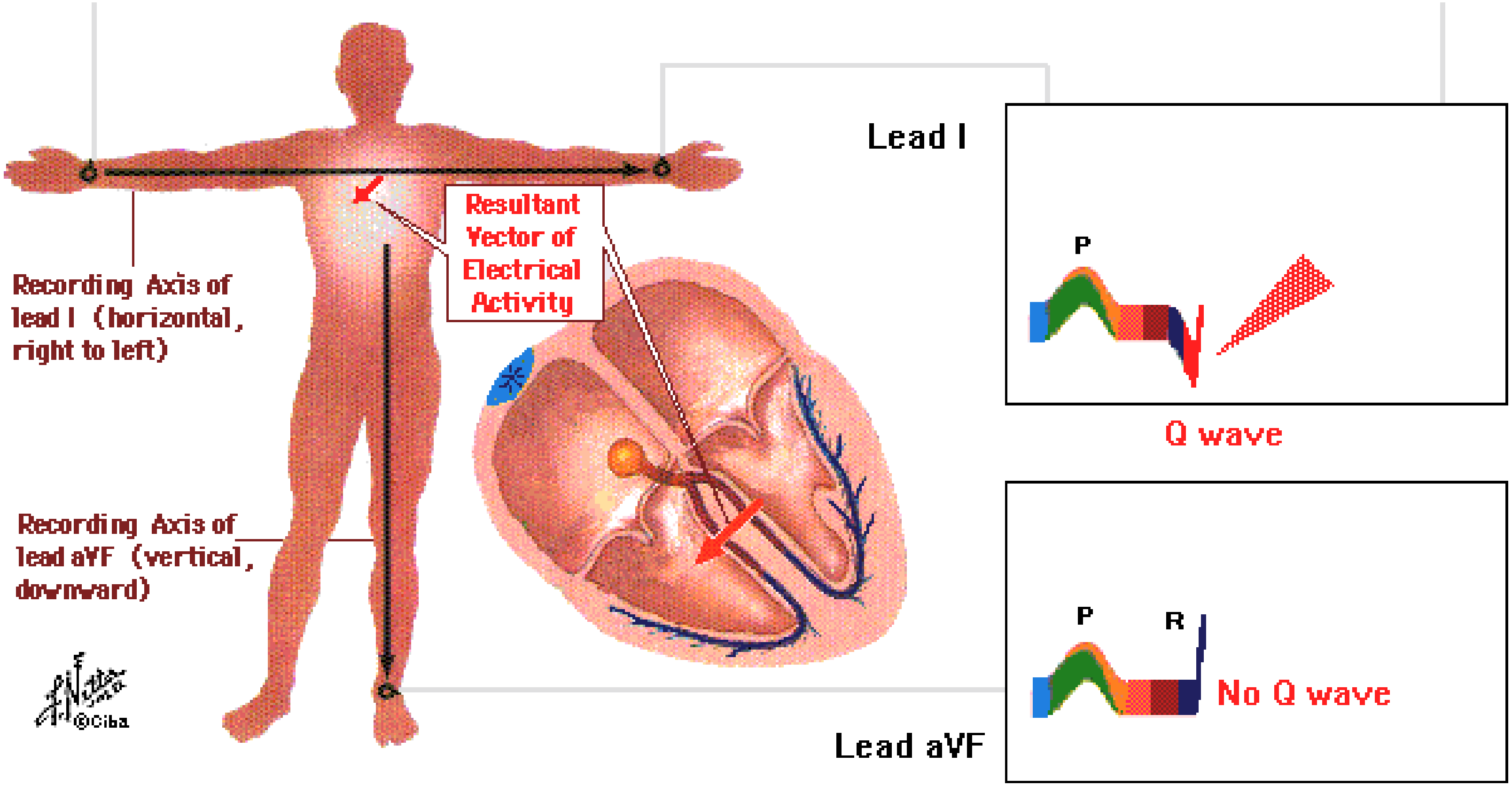
Normal sequence of depolarization and repolarization 1



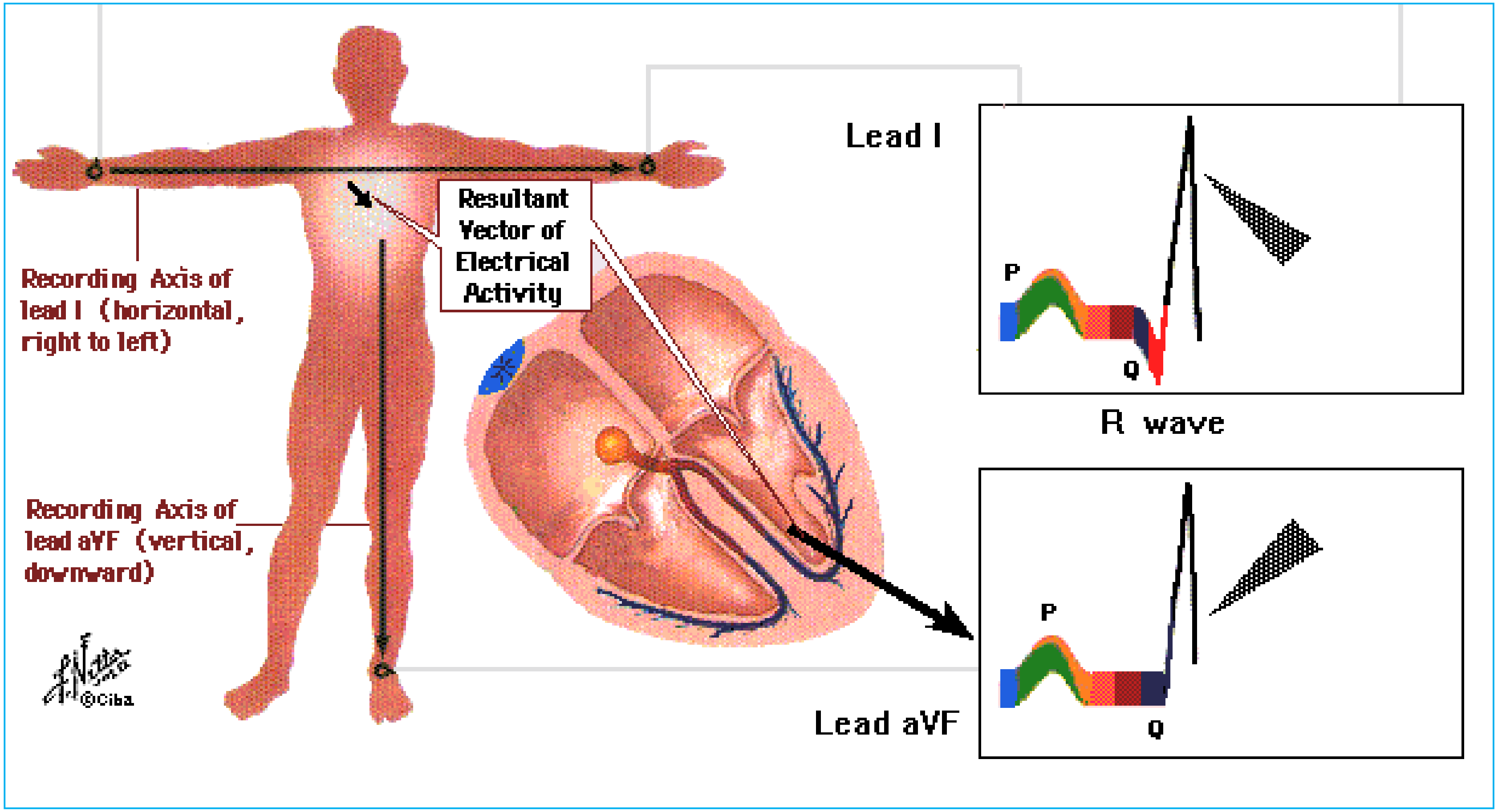
Normal sequence of depolarization and repolarization 2



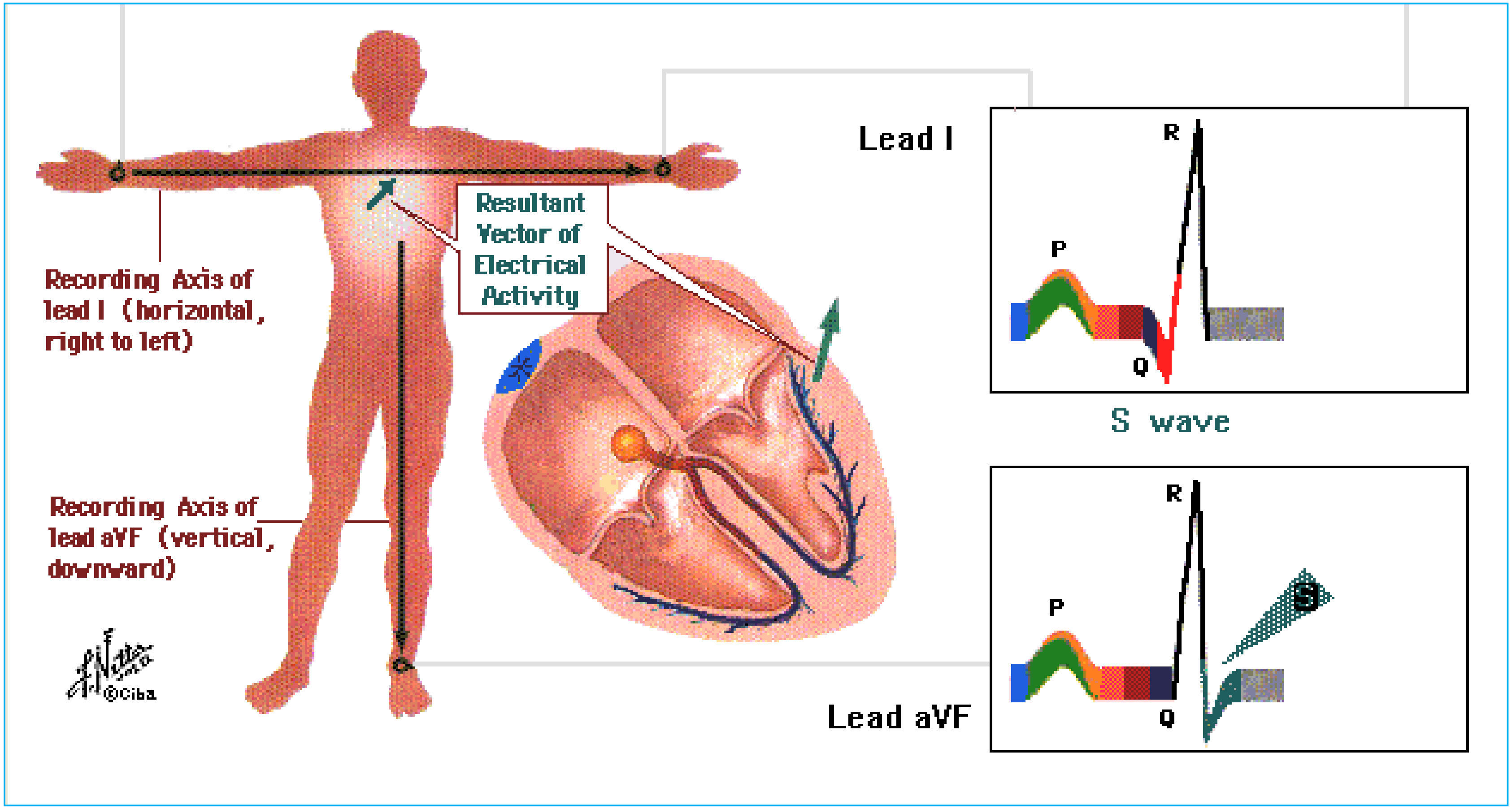
Normal sequence of depolarization and repolarization 3



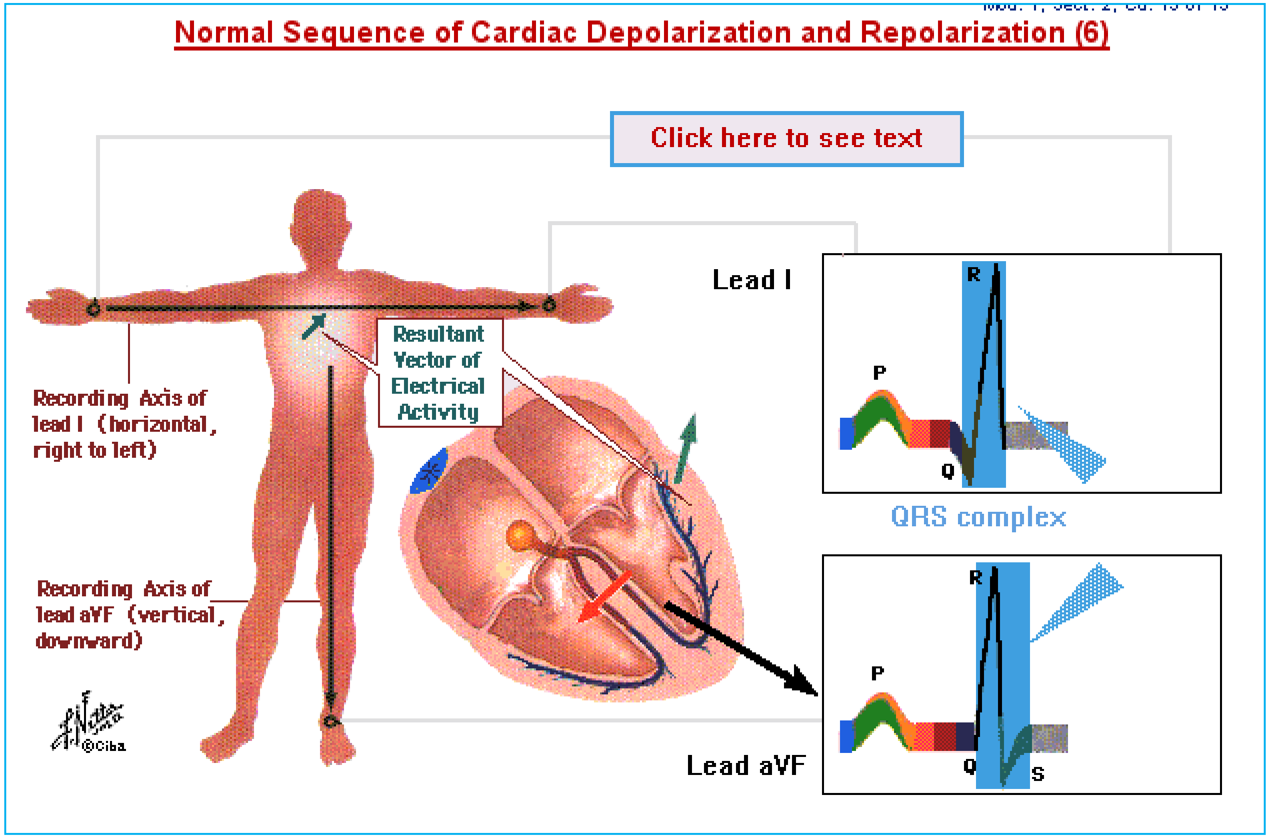
Normal sequence of depolarization and repolarization 4



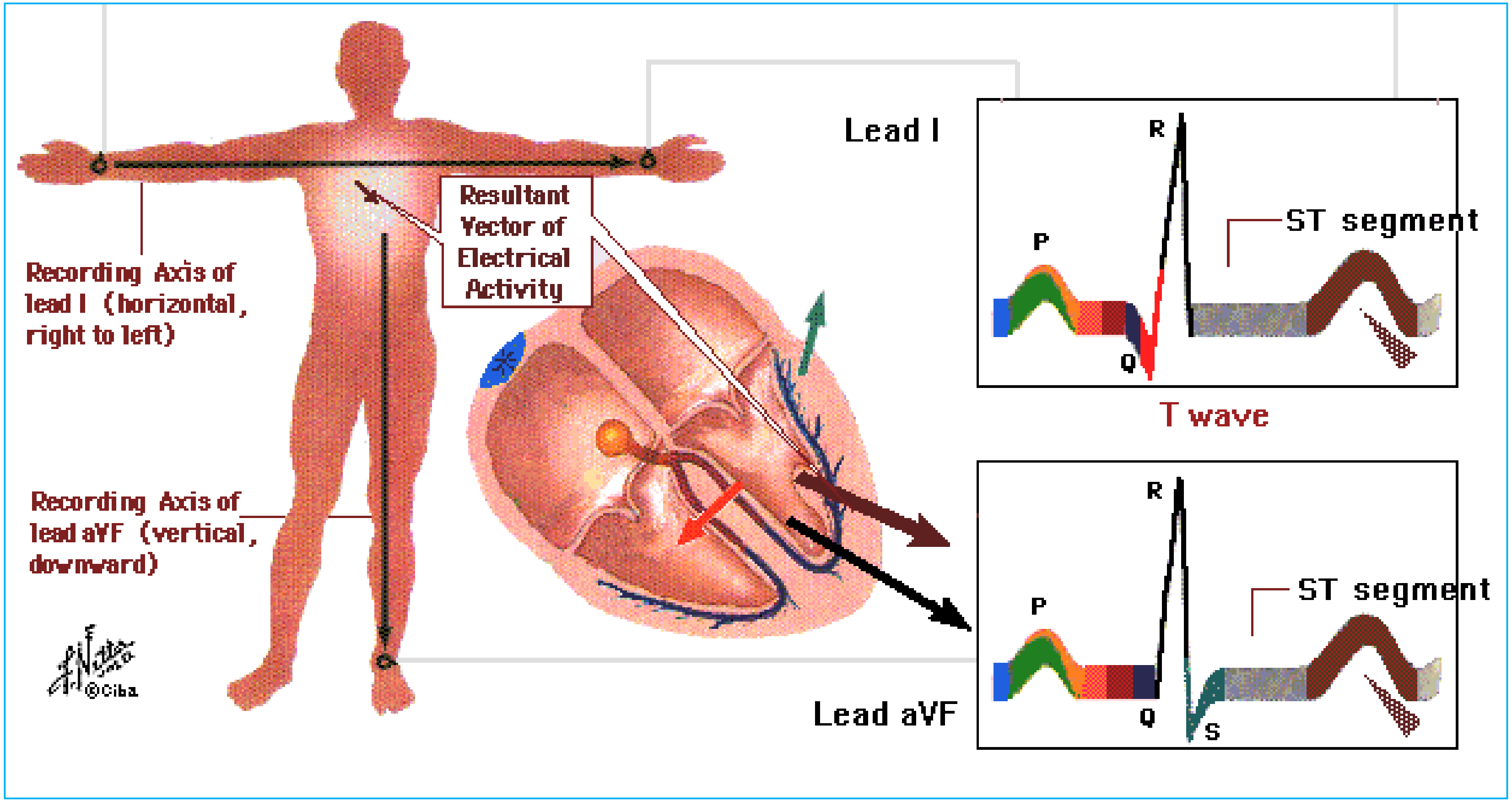
Normal sequence of depolarization and repolarization 5



Normal sequence of depolarization and repolarization 6



Normal sequence of depolarization and repolarization 7



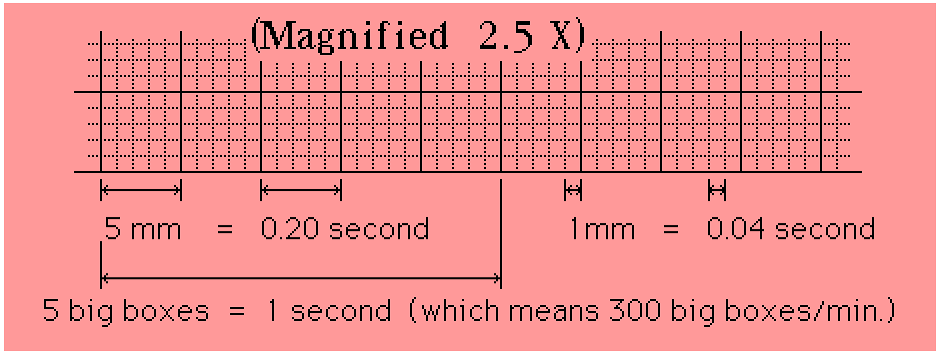
Normal ECG

- All ECG machines run at a standard rate (25 mm per second) and use paper with standard-sized squares.
- Each small square (1 mm) represents 40 ms (0.04 seconds), while each large square (5 mm) represents 200 ms (0.2 seconds). On the y axis, each small square represents 0.1 mV.
- ECGs may be recorded as a standard ‘12-lead ECG’ or individual ‘rhythm strips’.

Horizontal Measurements

Mod. 1, Sect. 3, Cd. 2 of 5

Horizontal Measurements



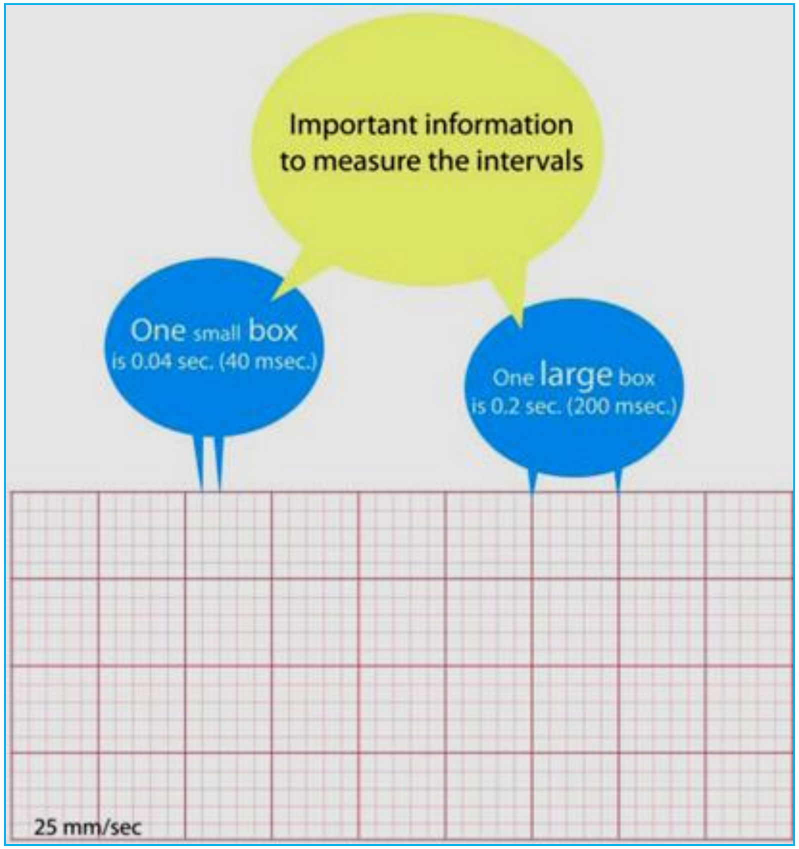
Since ECG paper routinely moves through the machine at a constant speed of 25 mm/second, the horizontal axis on paper represents time. Horizontal lines on standard ECG paper are ruled every millimeter, with darker lines every 5 mm. Five large boxes of 5 mm each equal 25 mm, or 1 second of time.

Thus, a single large box 5-mm wide represents 0.20 second, and a single box 1-mm wide is 1/5 of that, or 0.04 second.

Horizontal Measurements

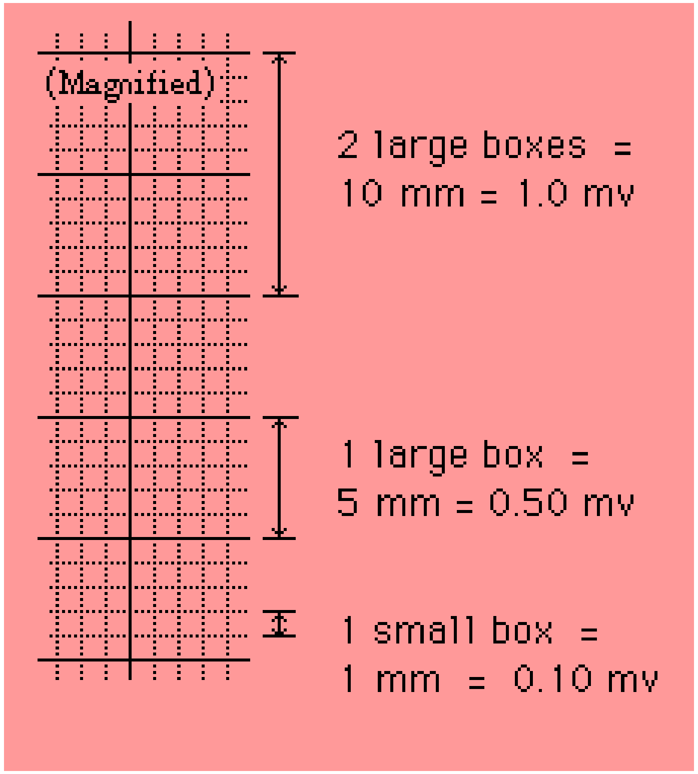
Small Box : 40 m sec

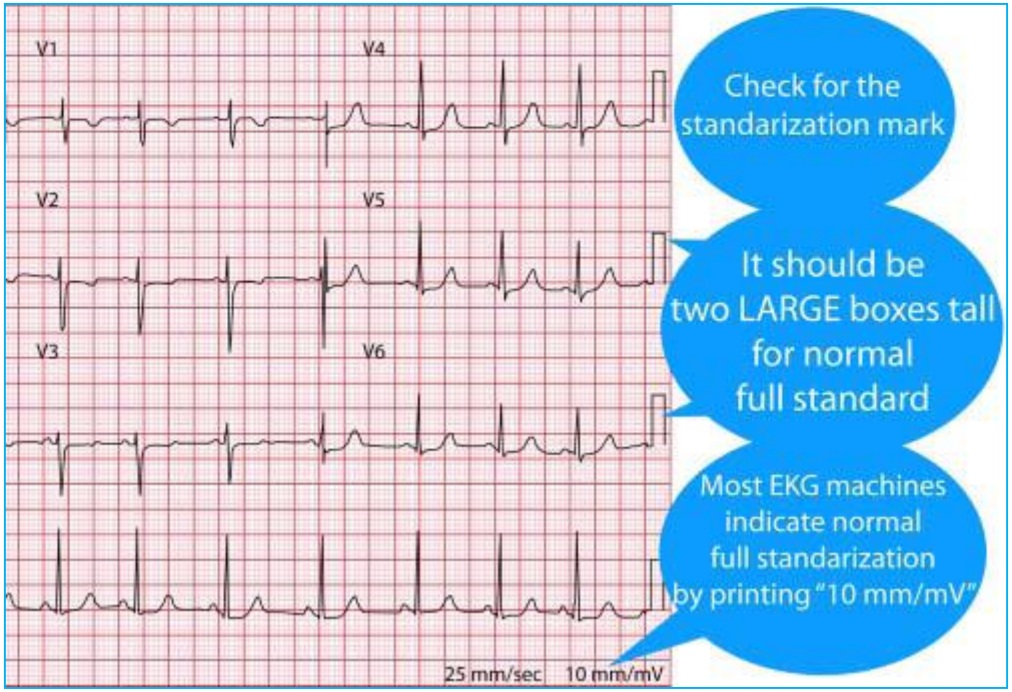
Large box :200 m sec



Vertical Measurements

vertical axis on ECG paper represents voltage. Each ECG machine must be calibrated so that a 1-mv standardization signal produces a deflection of exactly 10 mm, and this should be checked and recorded before every ECG is taken. Thus, each small box of 1 mm in the vertical direction represents 0.10 mv, one large box represents 0.50 mv, and two large boxes represent 1 mv.



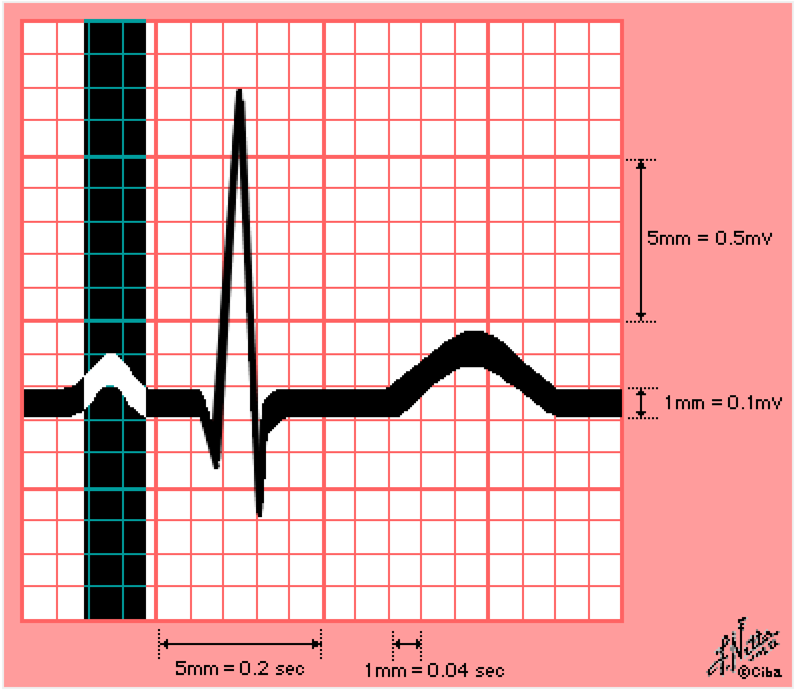

V1
V4
V2
V5
V3
V6
Check for the standarization mark
It should be two LARGE boxes tall for normal full standard
Most EKG machines indicate normal full standarization by printing "10 mm/mV"
25 mm/sec
10 mm/mV

The P wave

* P Wave

The P wave begins with the first upward deflection from the baseline and ends with return to the baseline.

The normal P wave measures less than 0.11 second in width, or not quite three small boxes.

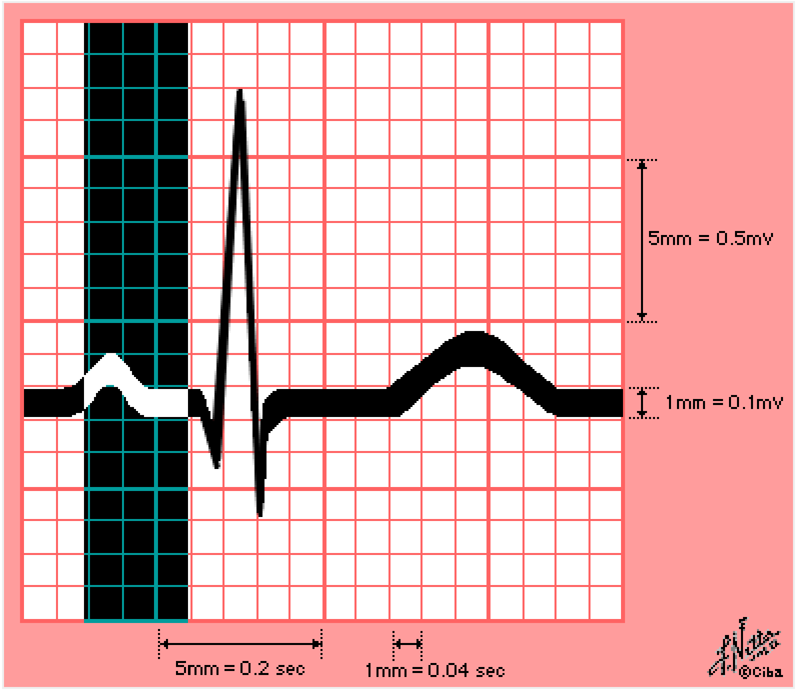


The P-R Interval

* PR Interval

The PR interval is measured from the first upward deflection of the P wave to the first deflection of the QRS from the baseline, whether negative (Q) or positive (R).

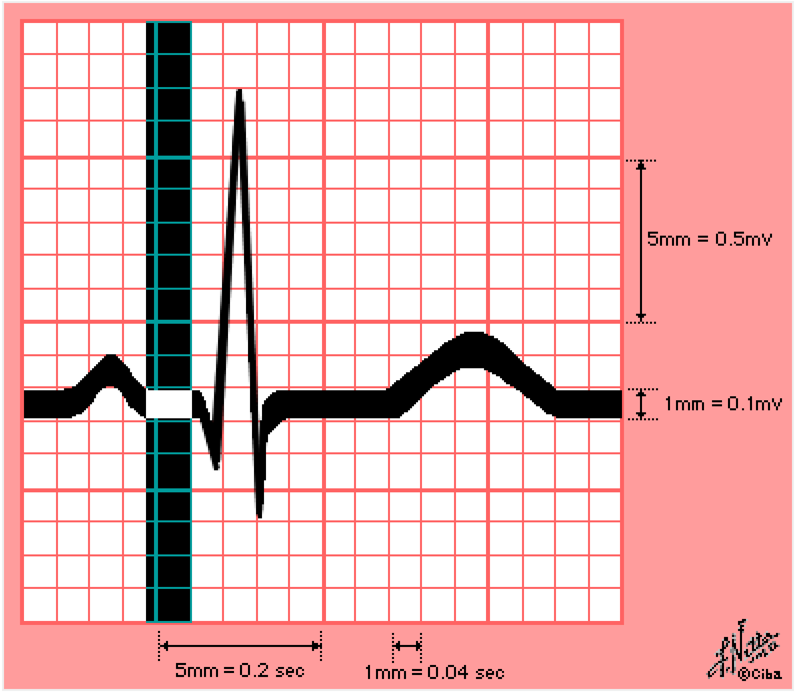
The normal PR interval varies slightly according to age and heart rate, but, for all practical purposes, it can be said to range from 0.12 to 0.20 second, or three to five small boxes.



The P-R Segment

* PR Segment

The PR segment is almost never measured.

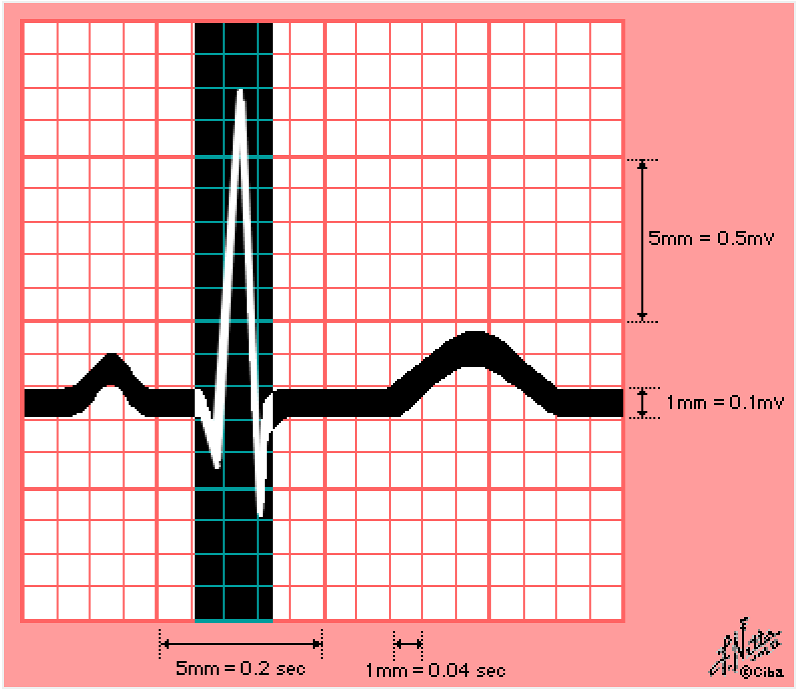


The QRS complex

* QRS Interval

The QRS interval is measured from the first deflection of the QRS from the baseline, whether negative or positive, to the eventual return of the QRS to the baseline.

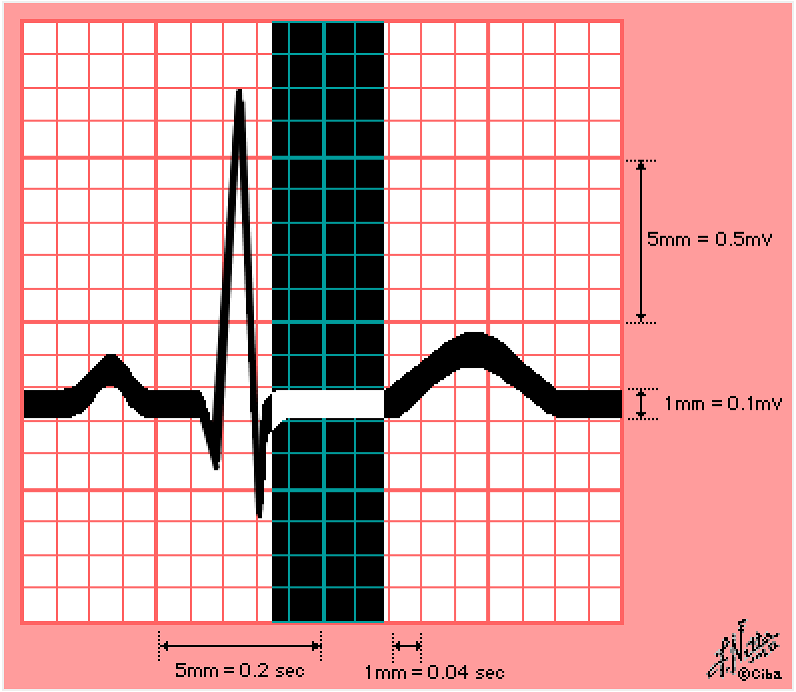
The QRS interval should be less than 0.10 second, or two and one-half small boxes.



The ST segment

* ST Segment

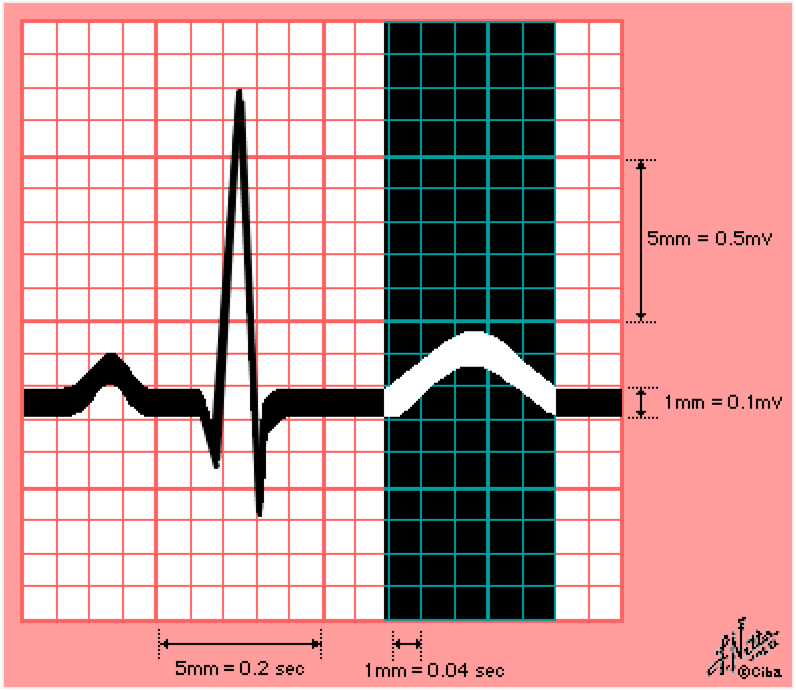
The ST segment runs from the return of the QRS to the base-line until the first upward or downward deflection of the T wave. While the duration of the ST segment is not generally of clinical significance, it is an exceedingly important portion of the ECG because of shifts up or down from the baseline. These shifts may be associ-ated with ischemic heart disease, pericarditis, or other conditions. Note that such shifts are generally measured at a point 0.08 second (80 msec), or two small boxes, after the end of the QRS complex.



The T wave

* T Wave

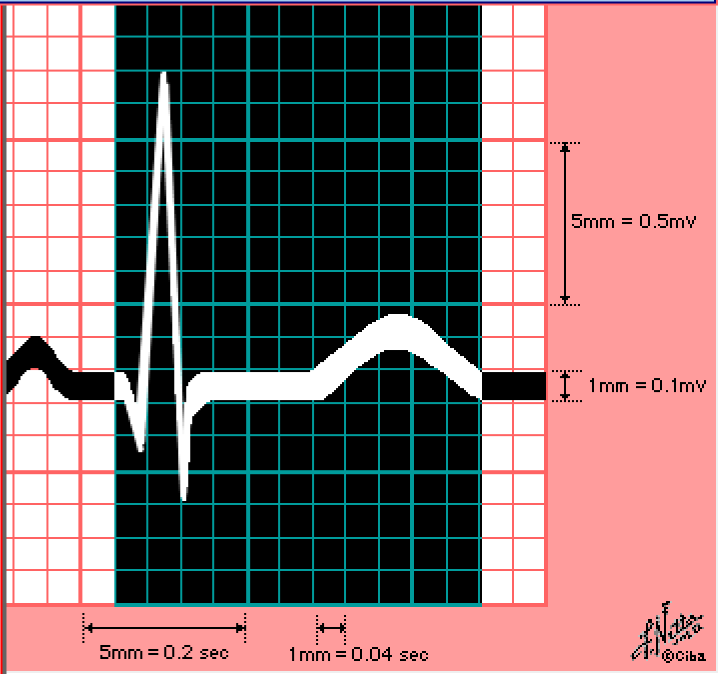
The T wave shows the wave of repolarization.



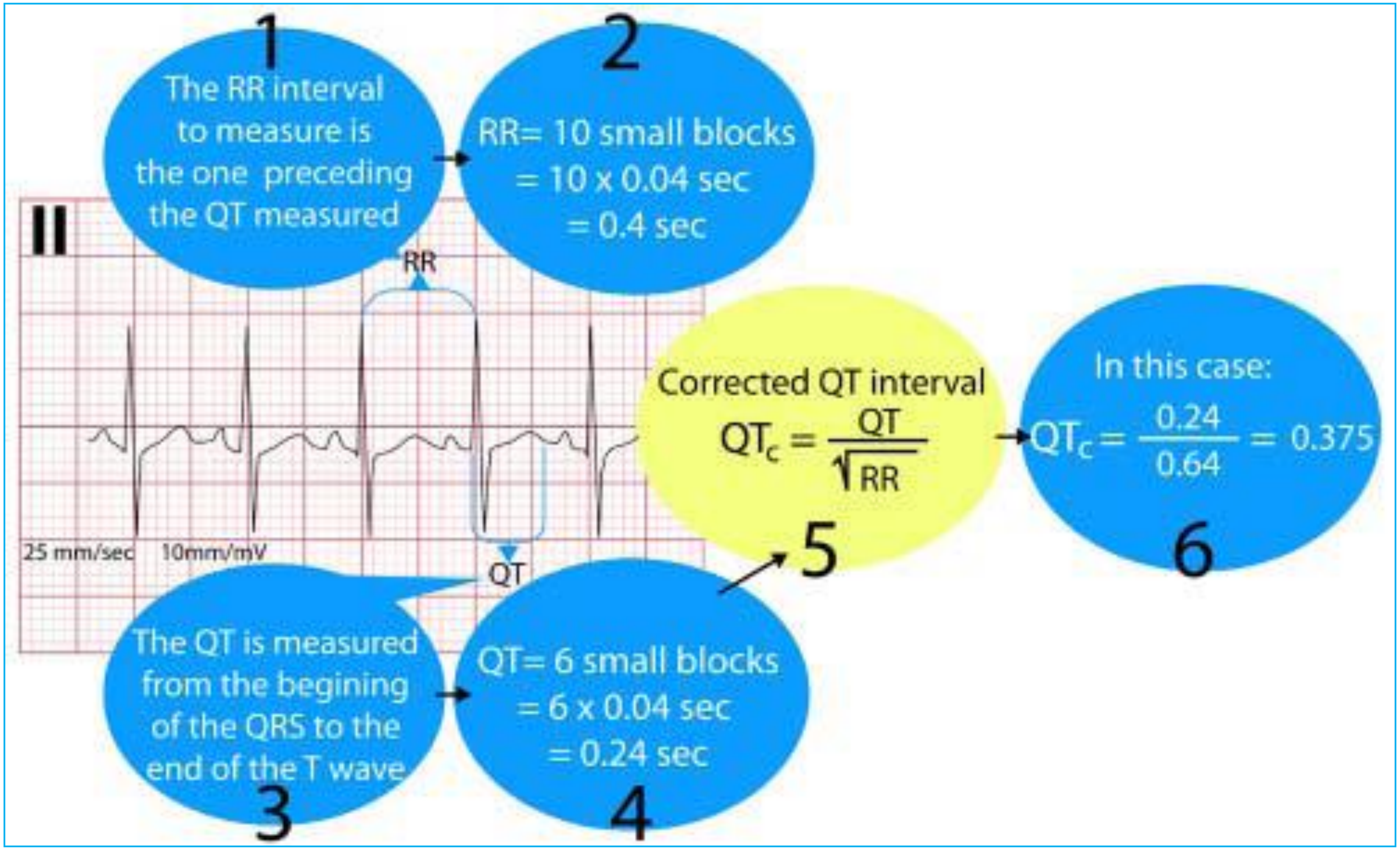
The Q-T Interval

The most common formula, that of Bazett, derives a corrected QT interval, or QTc, from the formula: QTc = QT / Square Root of RR Interval
Where RR interval is the time between two adjacent complexes, i.e., the cycle time.

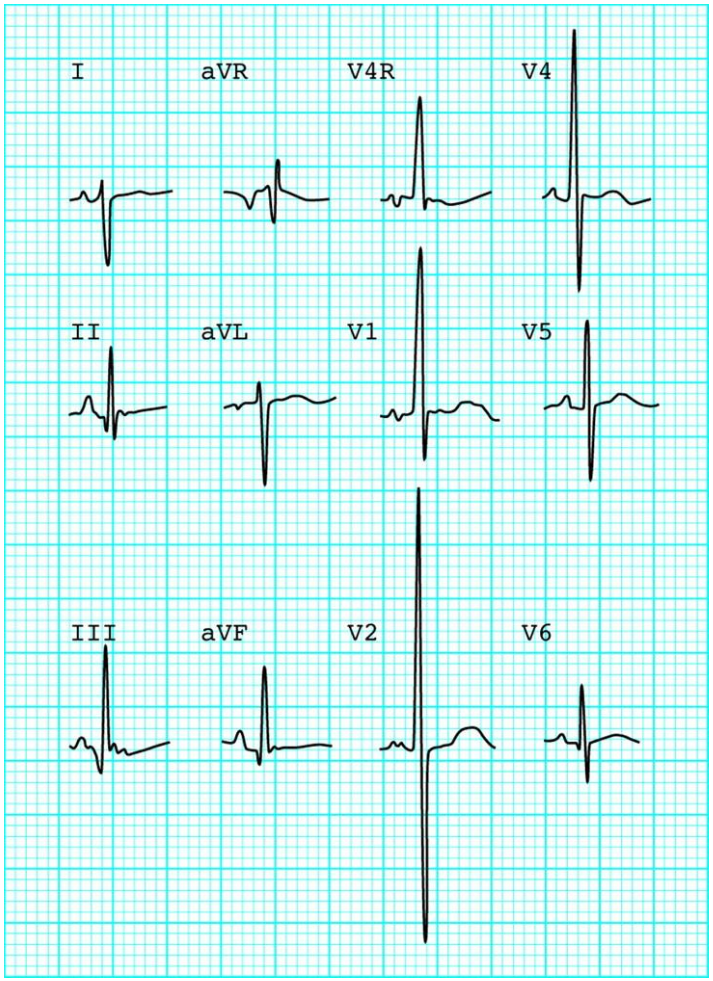
The QT interval is measured from the beginning of the QRS complex to the final return of the T wave to the baseline. The QT interval is markedly affected by heart rate, and formulas * or tables that take heart rate into account must be used to obtain the upper limits of normal. However, most electrocardiographers consult charts. * For the guidance of the beginning ECG reader, one might generalize that with normal heart rates, 60 to 100/minute, QT intervals are in the range of 0.30 to 0.40 second, and the maximum QT interval is generally about 10% longer in females than in males. Unless the heart rate is very slow, a QT interval exceeding 0.40 to 0.44 second is probably abnormally prolonged.

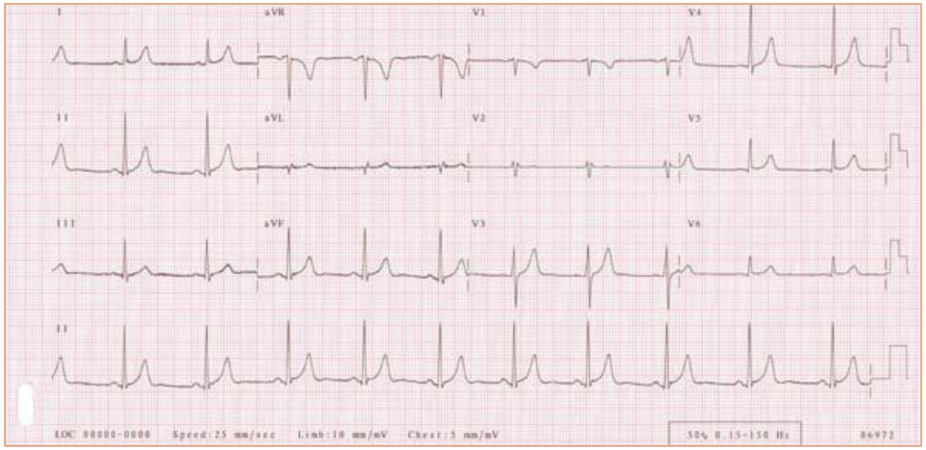


The Q-T Interval

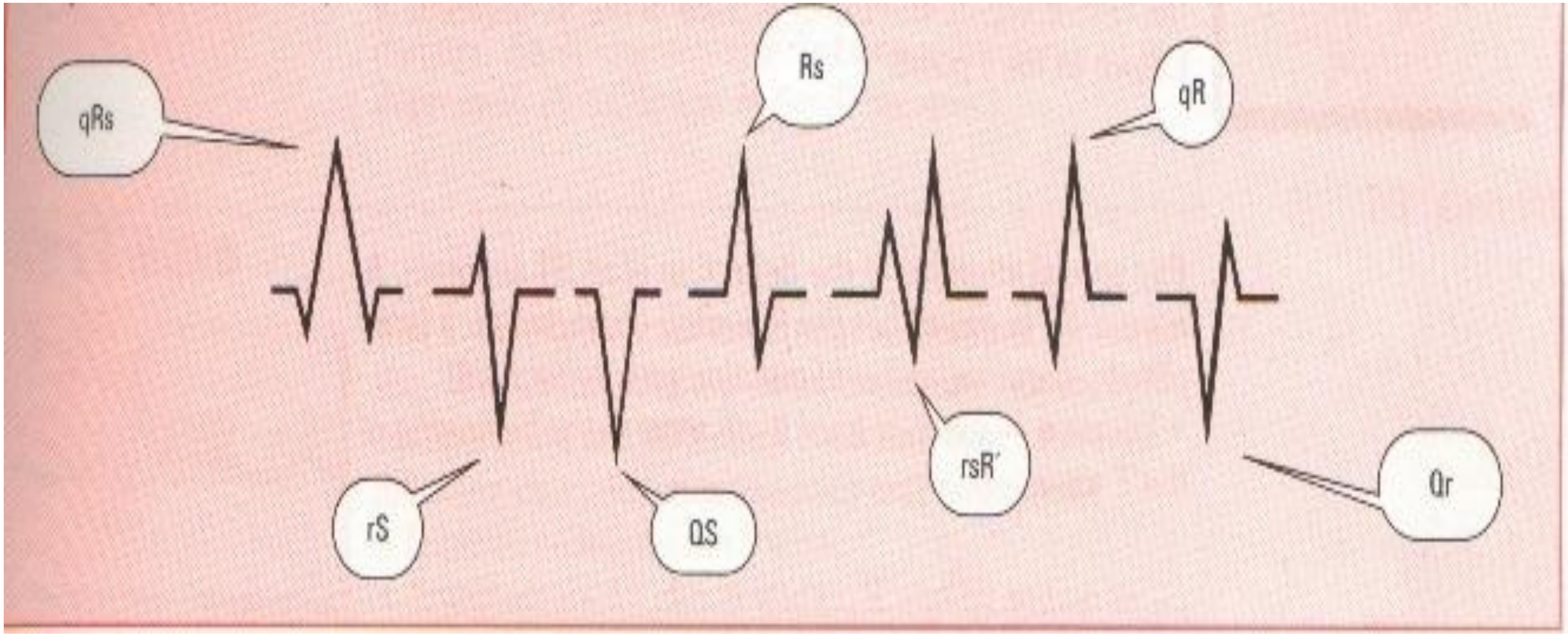


ECG Channels





QRS varieties



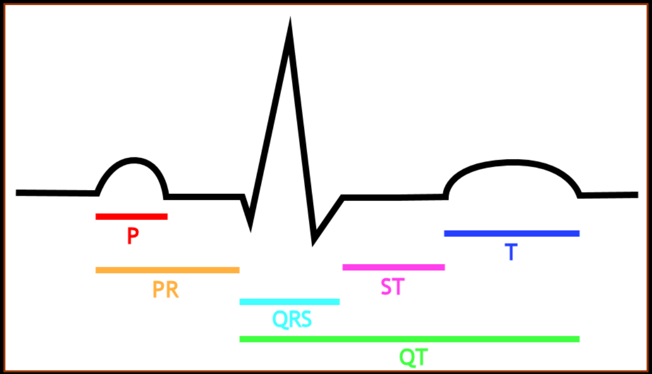
PART : II

Indications for ECG

- History suggestive of cardiac cause of Chest pain .
- History suggestive of cardiac syncope
- Suspected arrhythmia or conduction disturbance .
- Suspected toxic exposure
- Suspected electrolyte derangement
- Sepsis with suspicion for cardiac involvement
- Acute Myocarditis
- Initial diagnosis and follow up of Pericarditis
- Rheumatic fever or IE or KD
- As an initial tool searching for pathognomonic clues to certain CVHD or metabolic diseases .

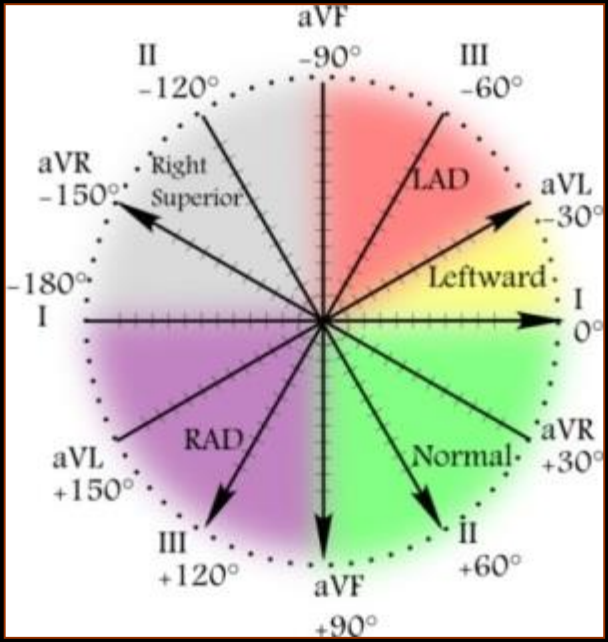
Components

- P-wave is atrial depolarization
- QRS is ventricle depolarization
- T-wave is ventricle repolarization
- PR interval may be short or long
- ST segment may be elevated or depressed
- QTc may be long or short

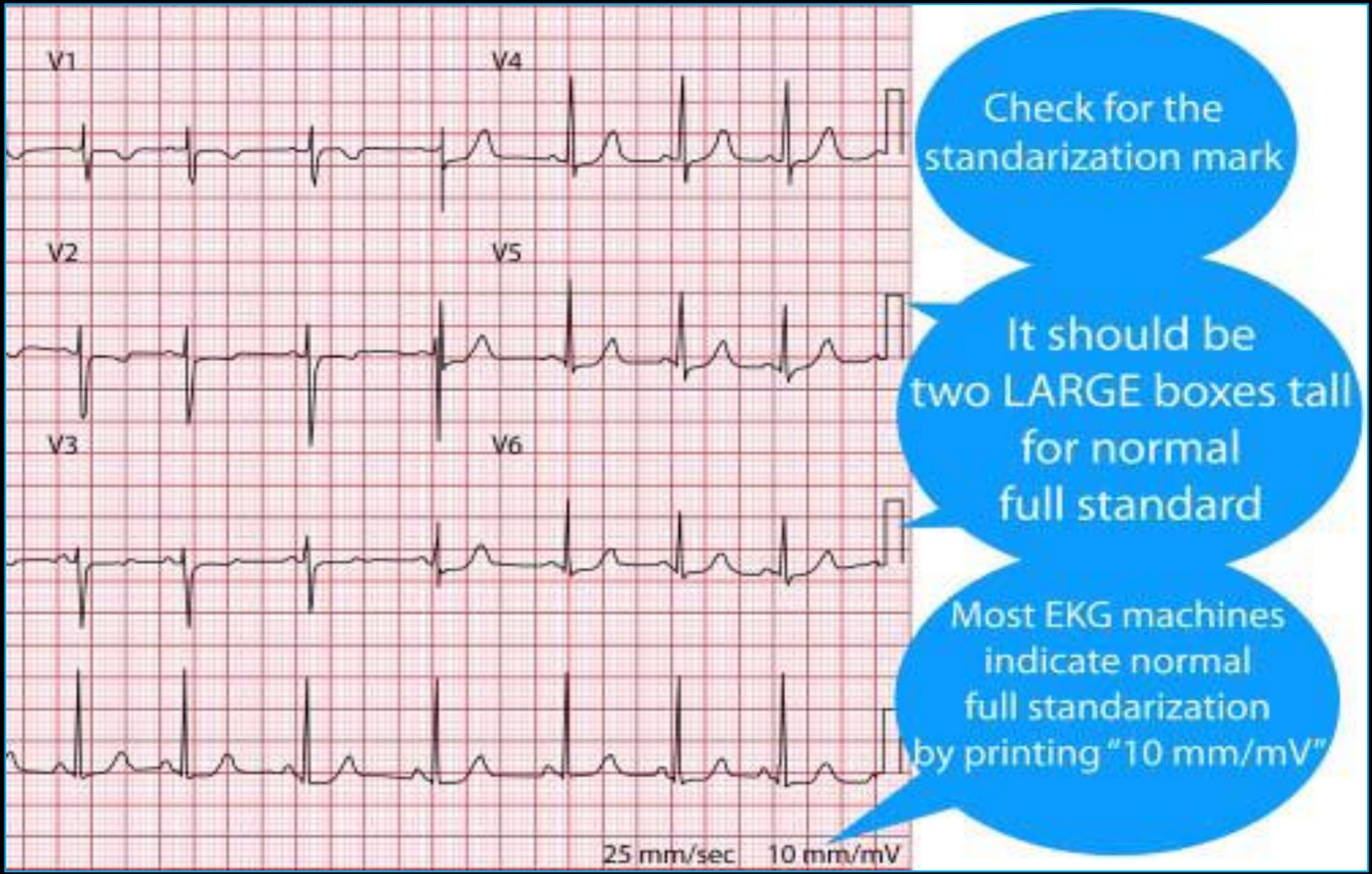


Tackling the ECG

- Rate
- Rhythm
- Axis
- Chambers
- Conduction
- Blocks
- Ischemia/infarction

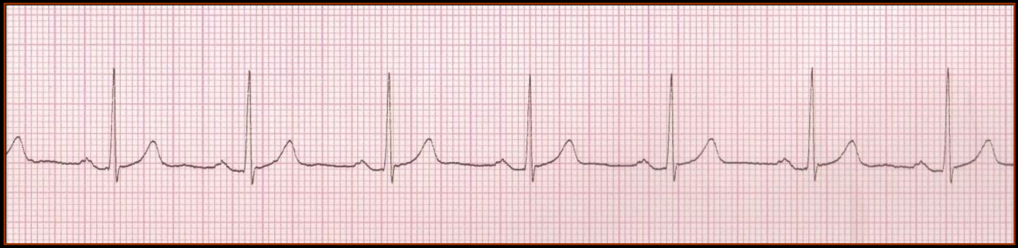


Always check for standardization mark and paper speed:



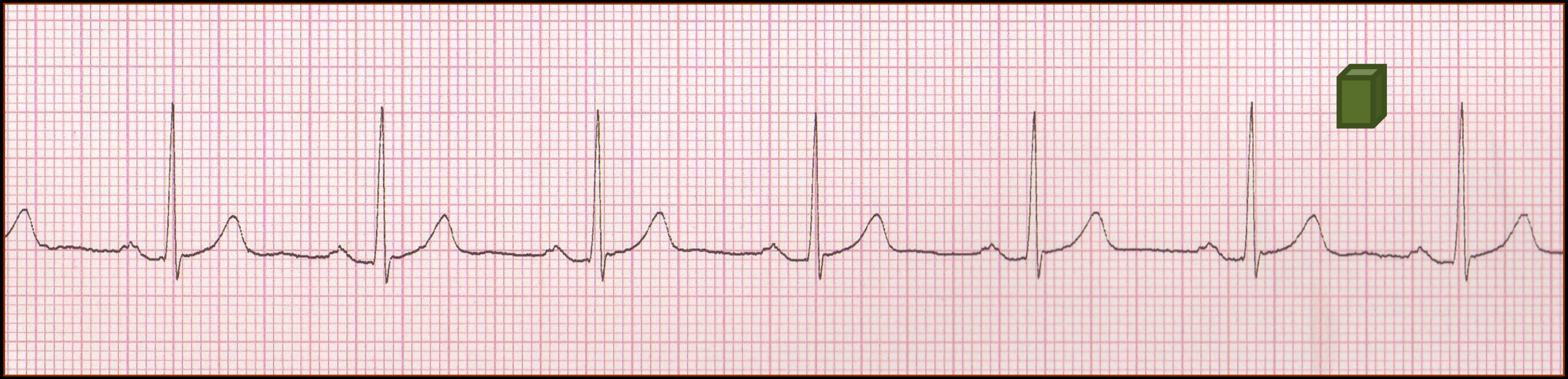
Tackling the ECG

I-Rate



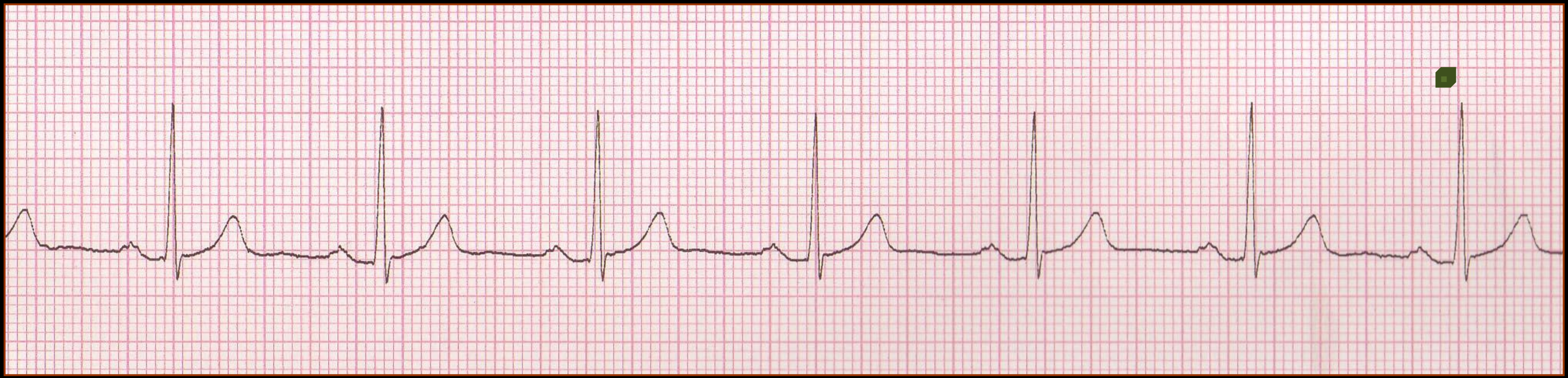
Rate

- Count *big boxes : 300/number of large boxes*
  - 300, 150, 100, 75, 60, 50

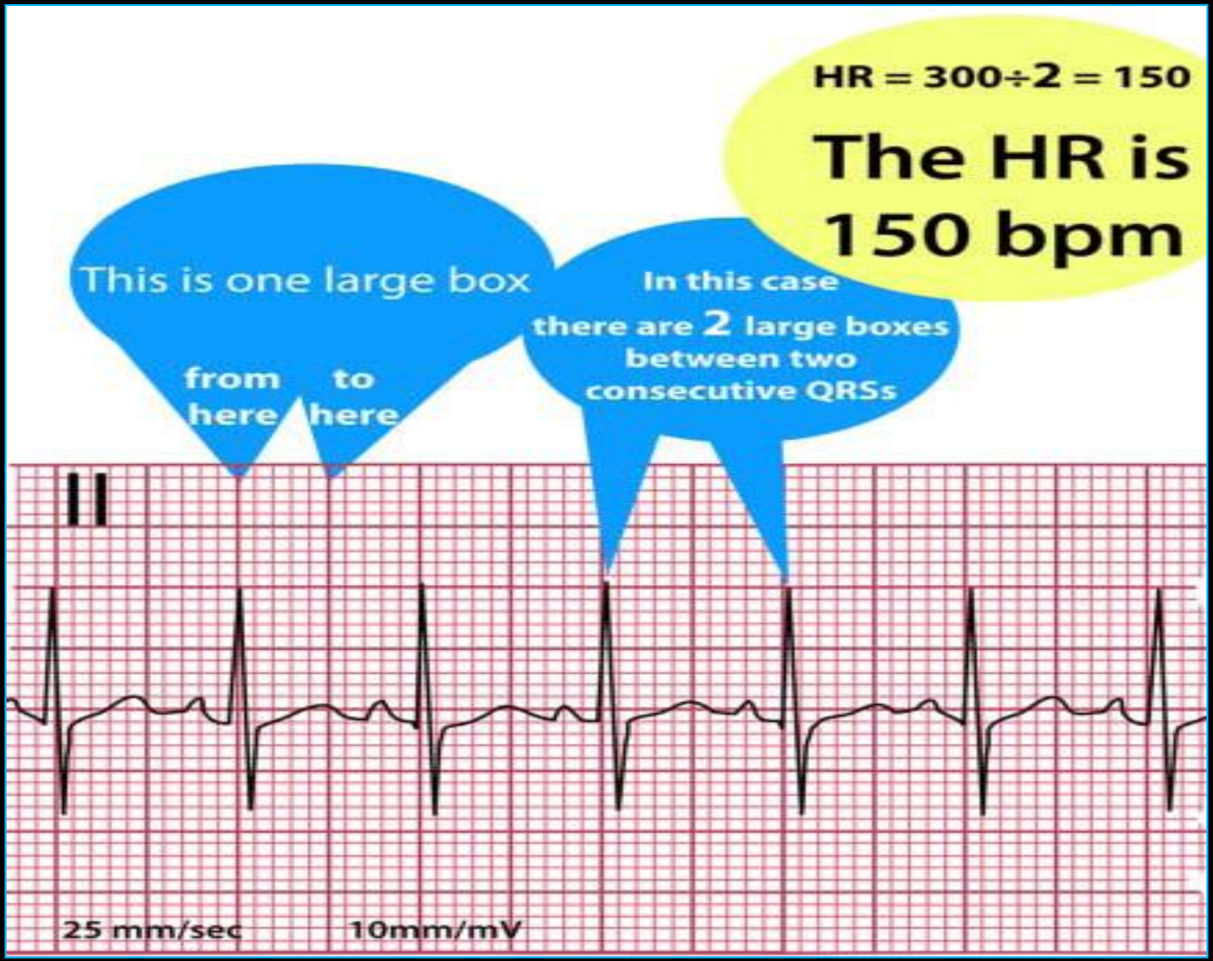


Heart Rate

- Count *small boxes :1500/number of small boxes*
  - 300, 150, 100, 75, 60, 50

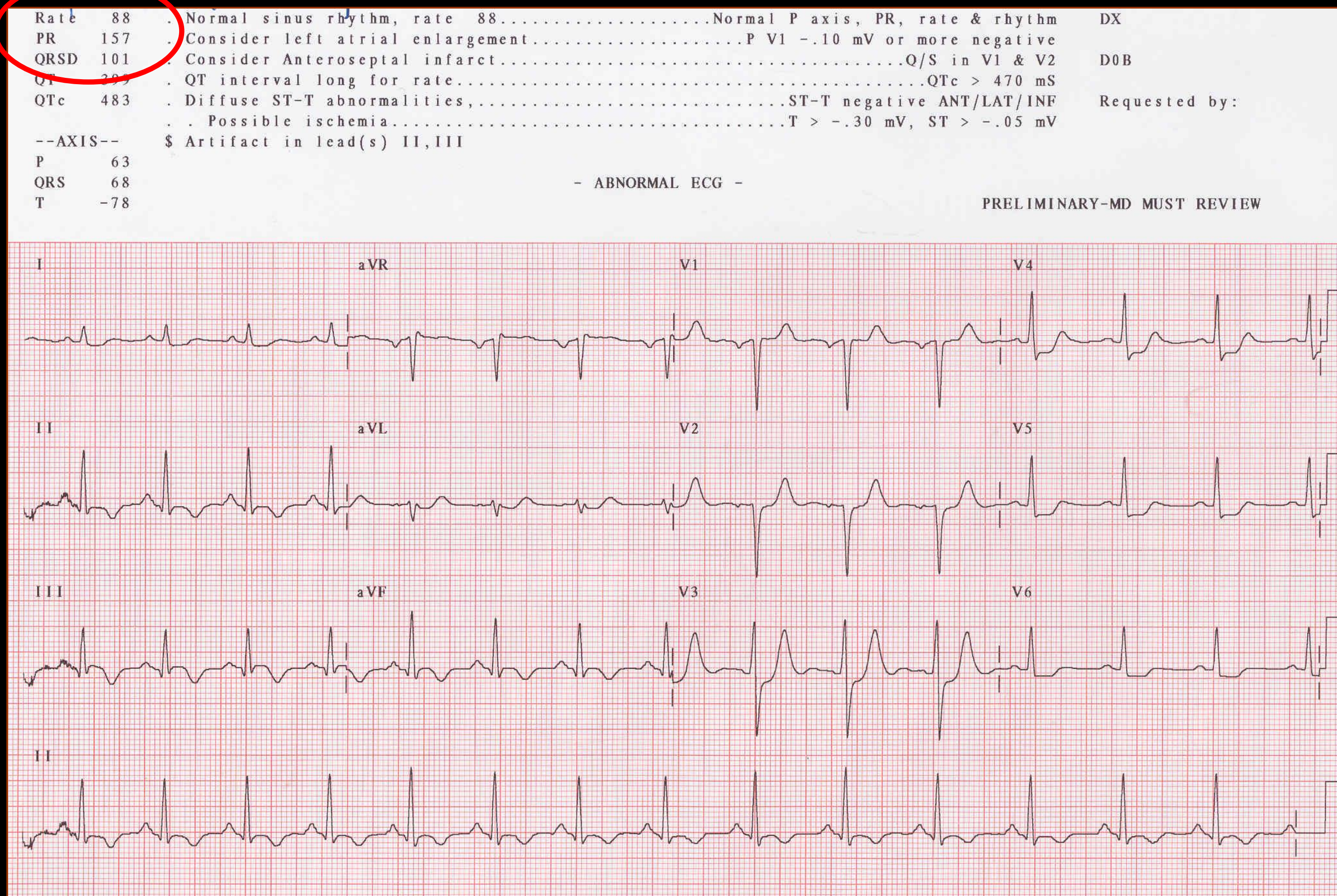


Heart Rate



HR = 300÷2 = 150
The HR is 150 bpm
This is one large box
from here
to here
In this case there are 2 large boxes between two consecutive QRSs
II
25 mm/sec
10mm/mV

...or look at the top of the page



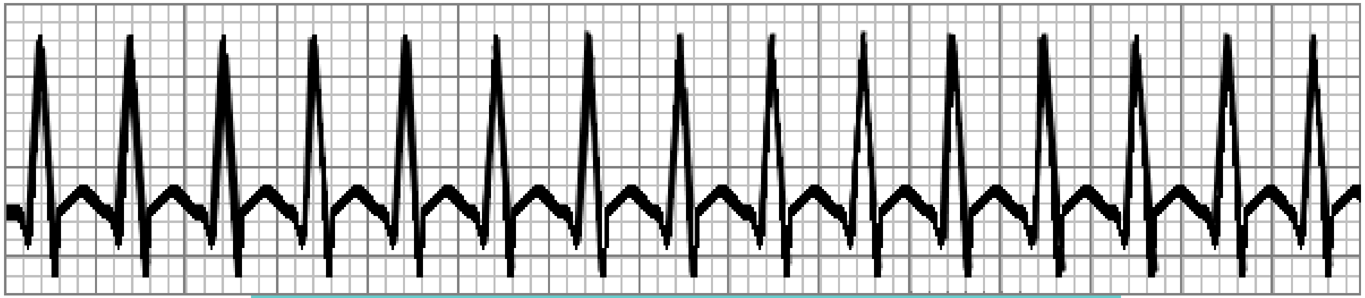
Rate : Regular Rhythm

Recall that ECG paper moves through the machine at a constant speed of 25 mm/second, and each large box is 5-mm wide. Hence, 5 large boxes pass by in 1 second, and 60 x 5, or 300, boxes move through in 1 minute.

Thus, we know, for example, that if there is a QRS complex every 2nd large box, the heart rate would be 300/2, or 150/minute.

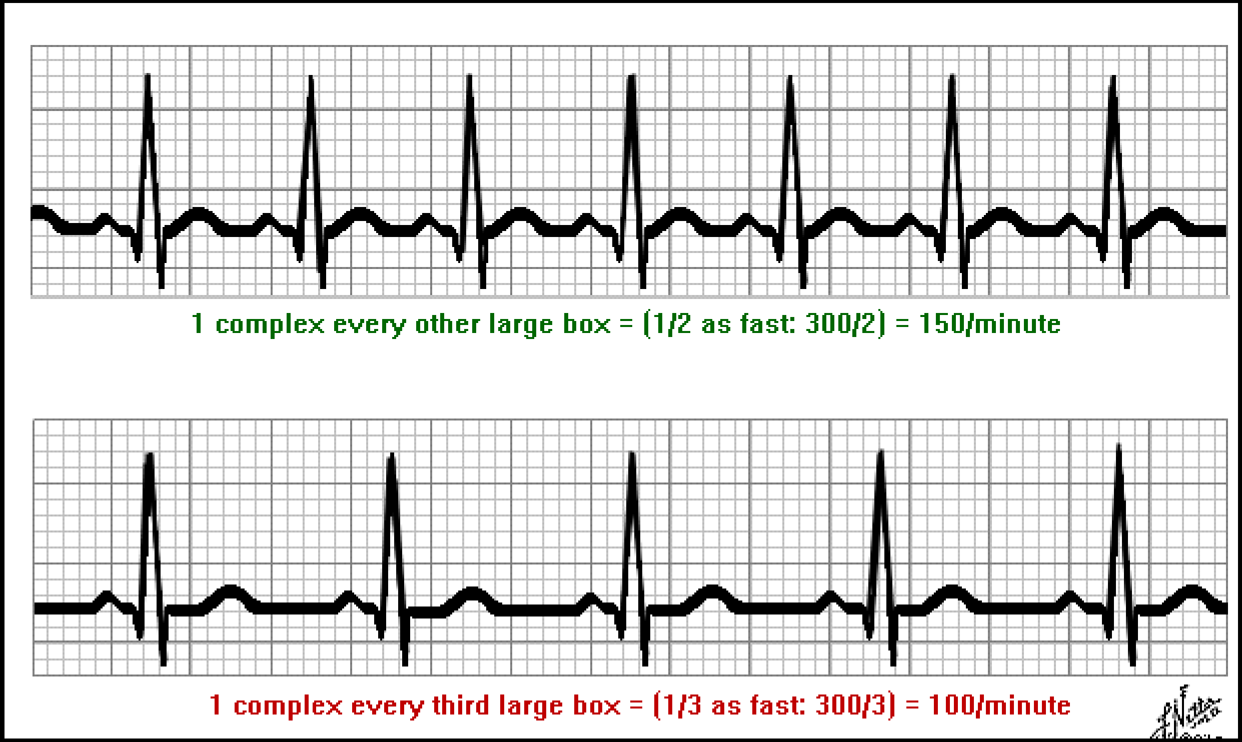
Here is the formula:

Heart rate = 300 / [# of large boxes for 1 complete cycle]

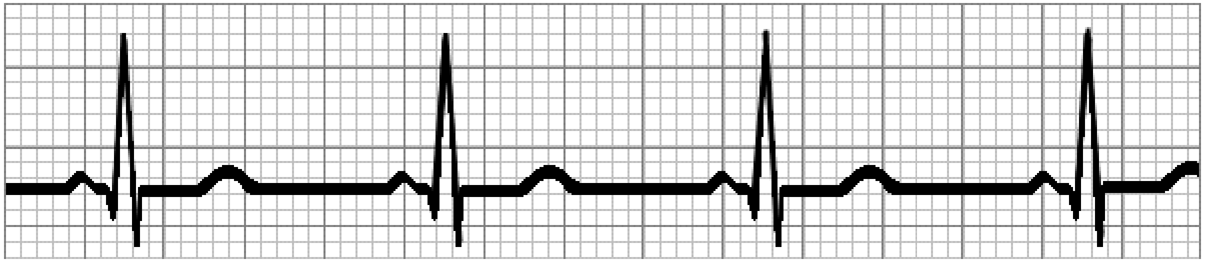


Very fast rate: 1 complex every large box = 300/minute

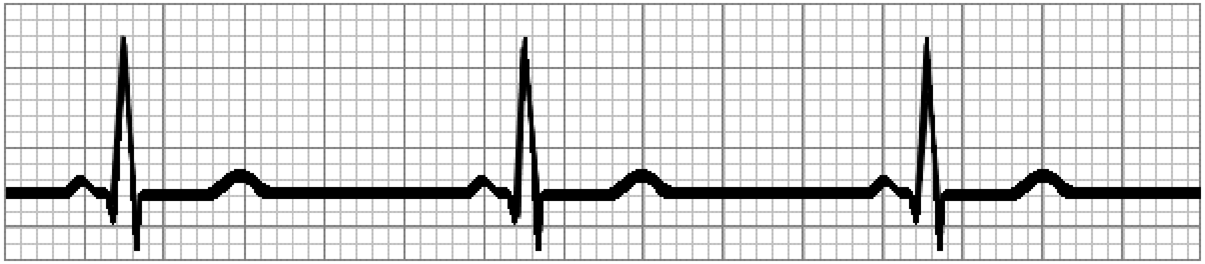
Rate : Regular Rhythm



Rate : Regular Rhythm

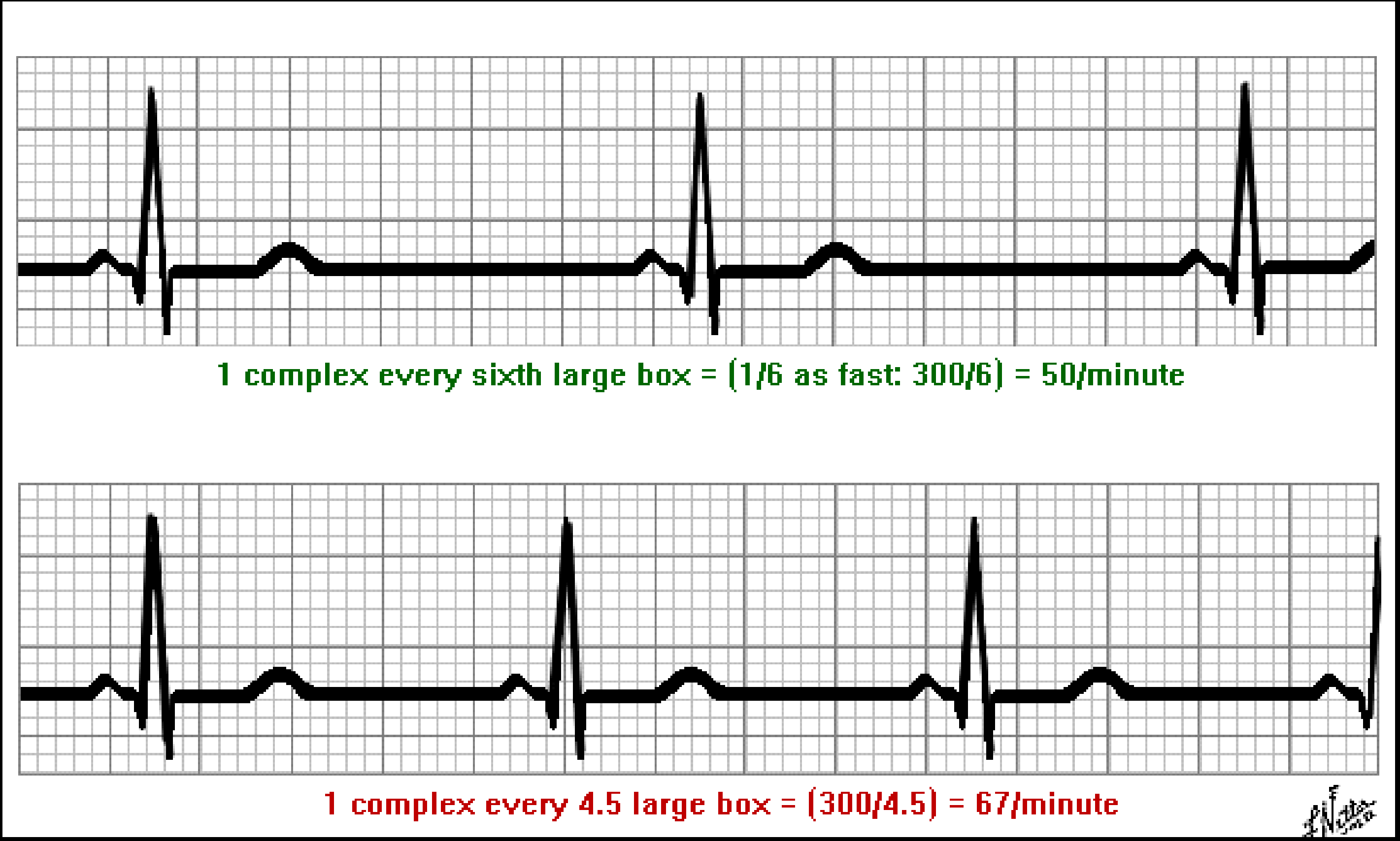


1 complex every fourth large box = (1/4 as fast: 300/4) = 75/minute



1 complex every fifth large box = (1/5 as fast: 300/5) = 60/minute

Rate : Regular Rhythm



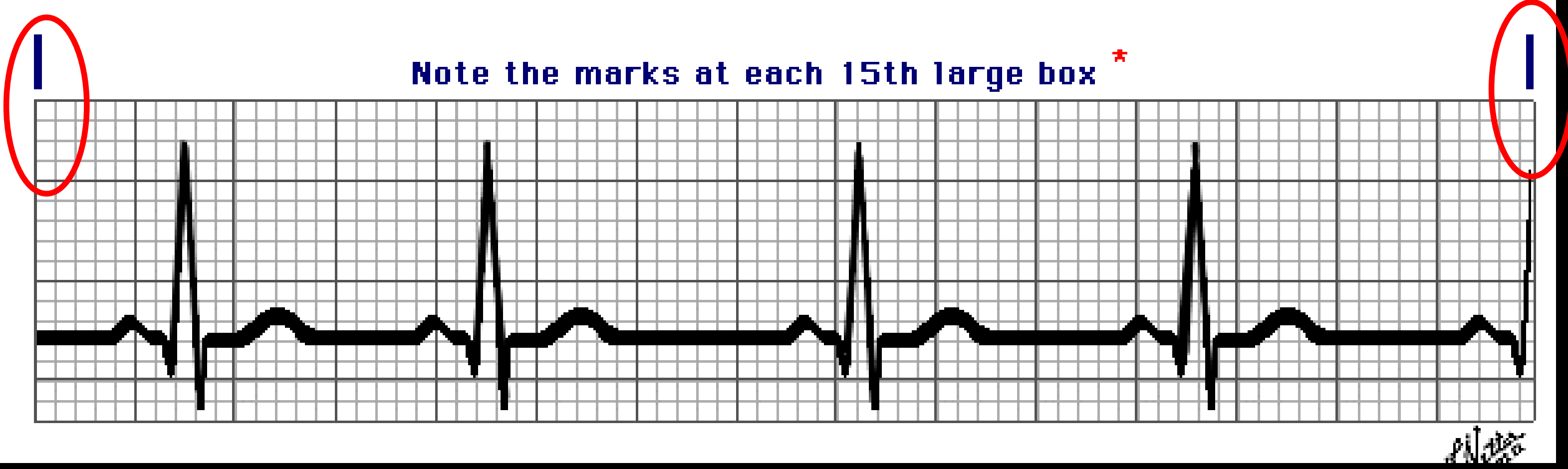
Rate : Irregular Rhythm

On this trace we can see that there are just slightly less than 4 beats occurring in this 3-second interval. In one minute, then, we estimate just less than 80 beats per minute.

For Irregular Rhythms, rate calculations using intervals between complexes are unreliable. Instead, we must actually COUNT THE NUMBER OF COMPLEXES over a period of time.

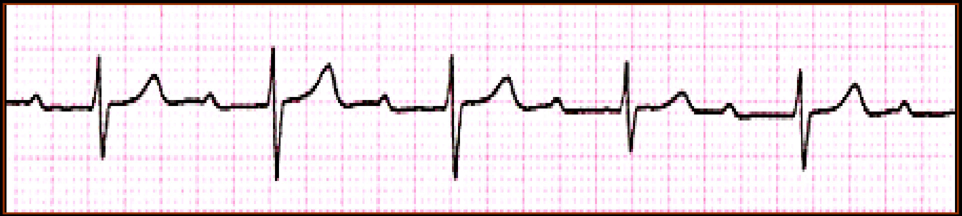
Use the SECONDS caliper to confirm that the following traces show irregular rhythms.

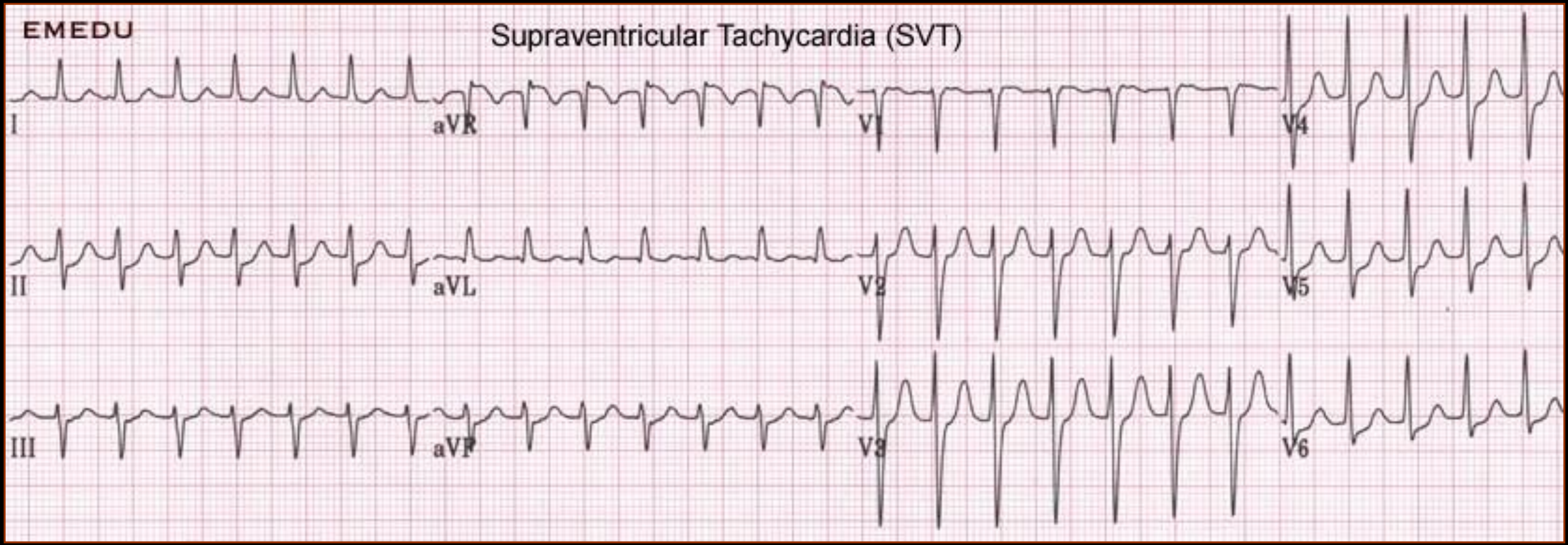
Note the marks at each 15th large box

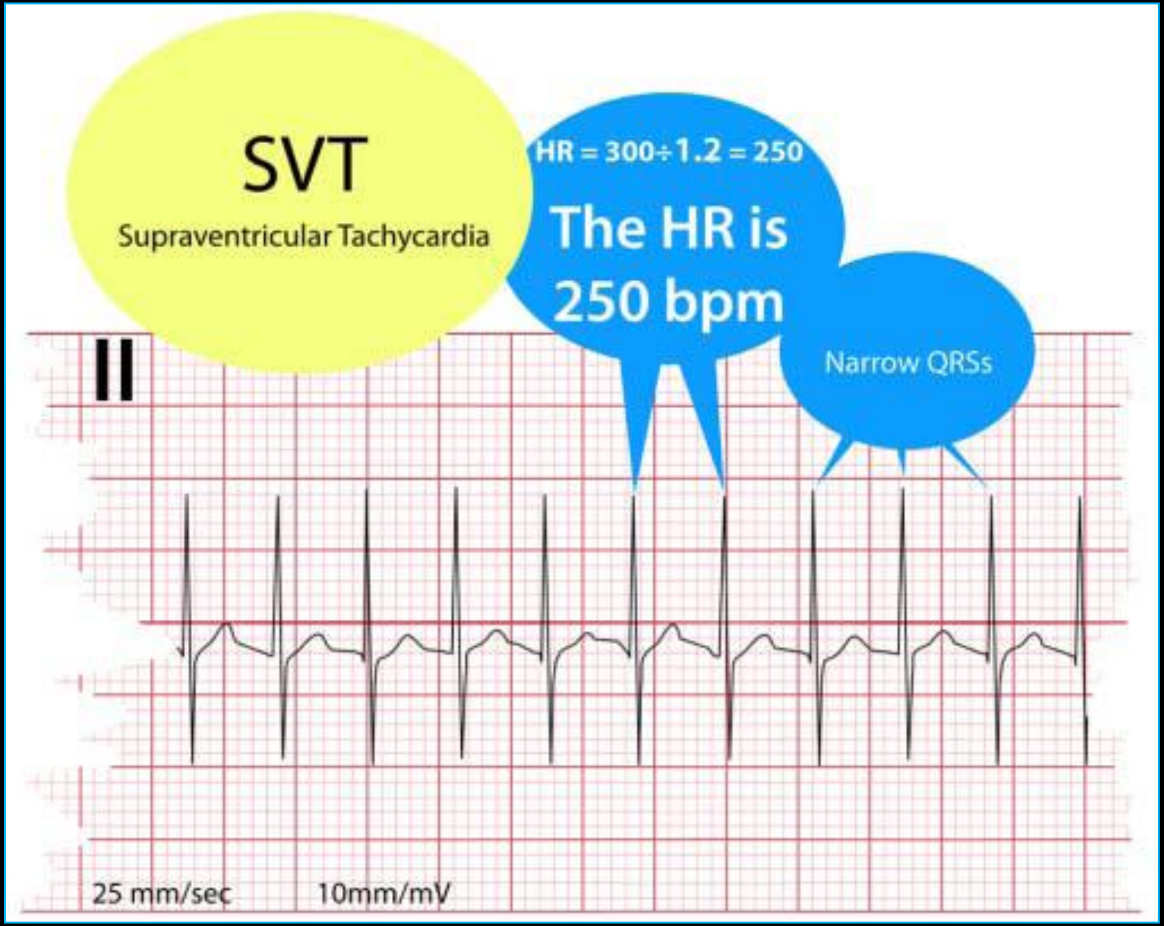


Rate : Irregular Rhythm

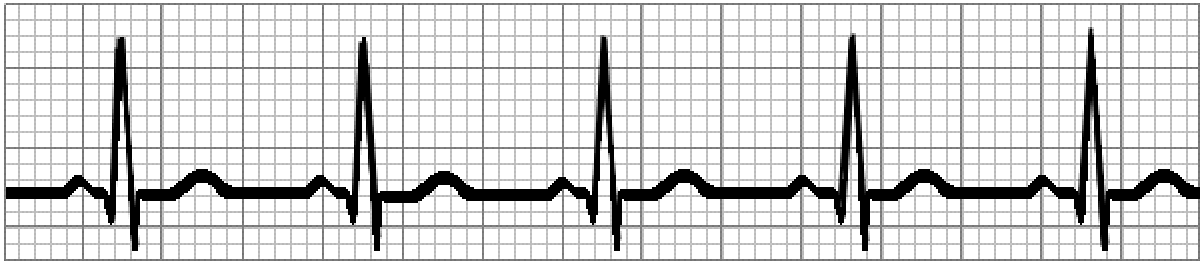
How to Calculate the heart rate in the 3 rhythm strips?







SVT
Supraventricular Tachycardia
HR = 300÷1.2 = 250
The HR is 250 bpm
Narrow QRSs
II
25 mm/sec
10mm/mV

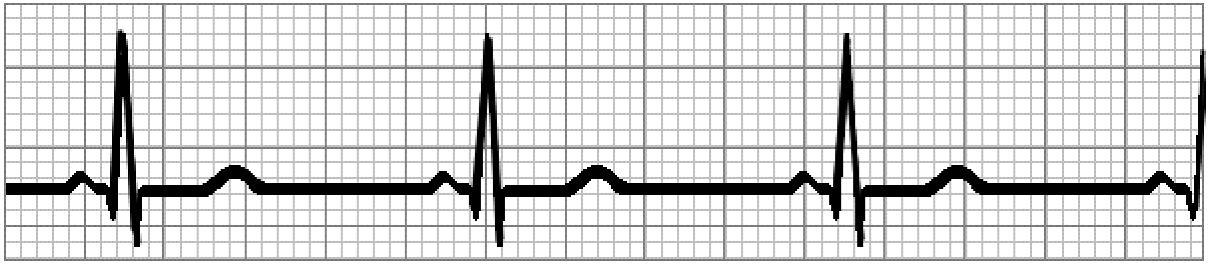


What is the heart rate shown in the tracing above?
Click the answer below.

1. 50/minute
2. 75/minute
3. 100/minute
4. 83/minute

What is the heart rate shown in the tracing above?
Click the answer below.

1. 50/minute
2. 67/minute
3. 75/minute
4. 83/minute

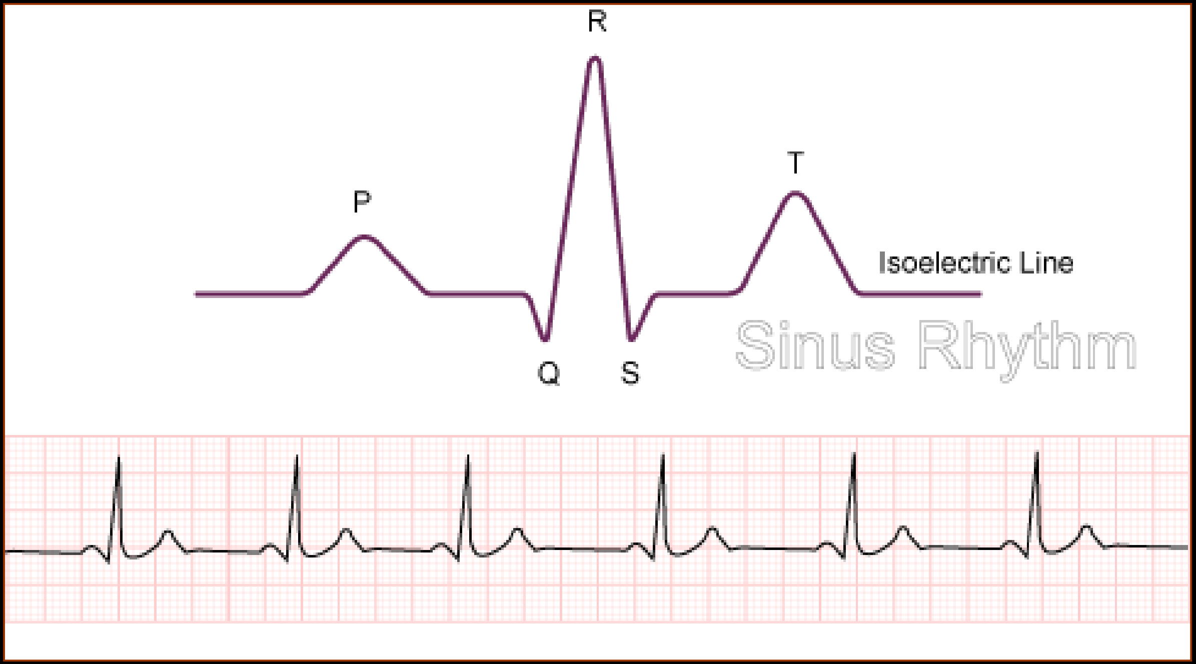


What is the heart rate shown in the tracing above?
Click the answer below.

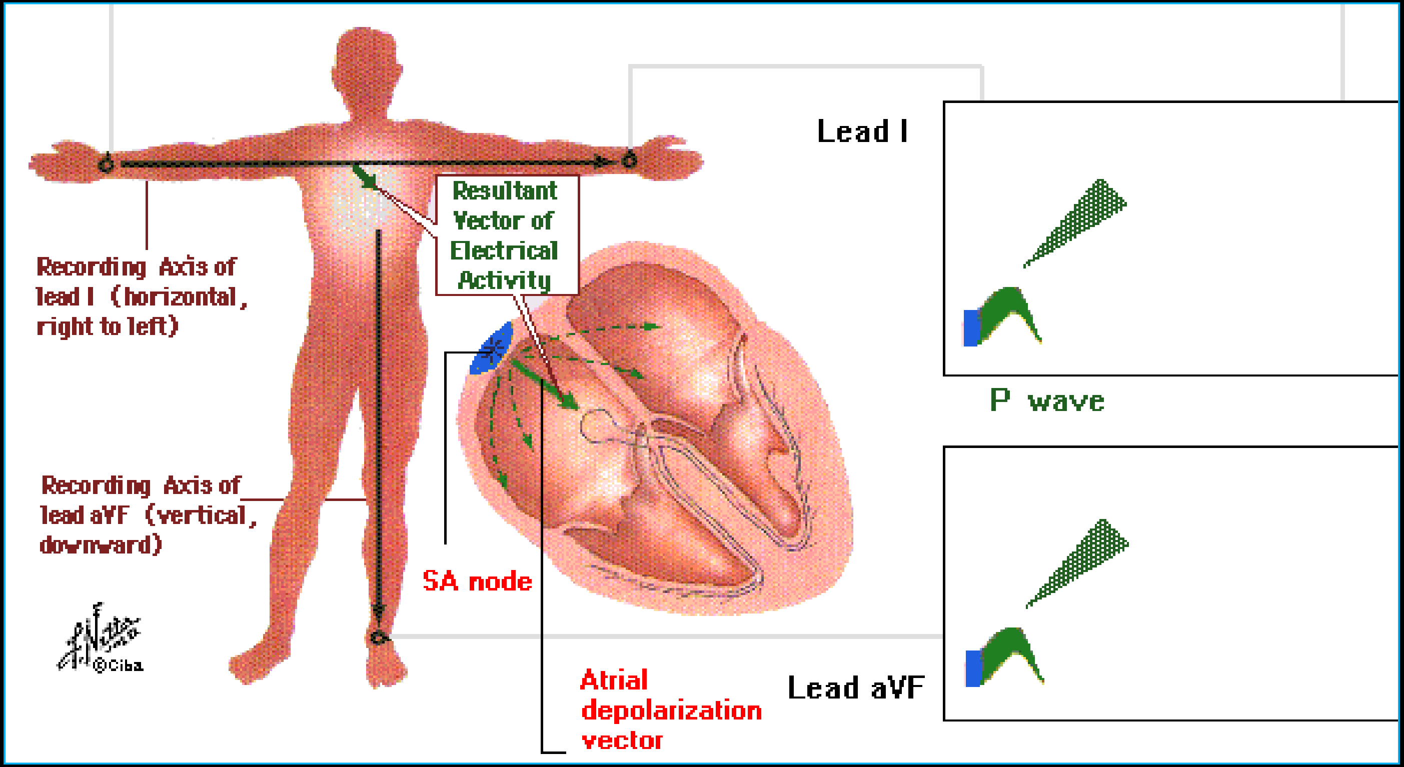
1. 50/minute
2. 67/minute
3. 75/minute
4. 83/minute

II-Rhythm

Sinus rhythm



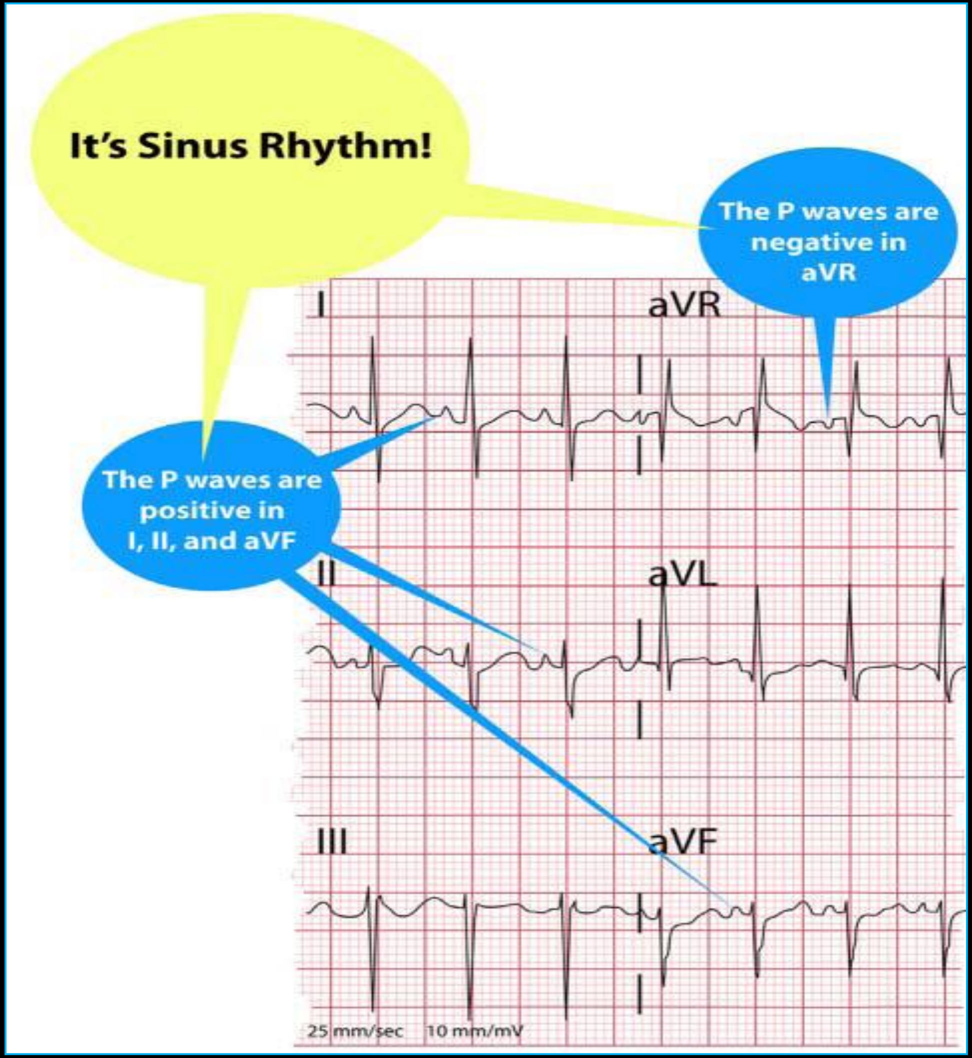
Normal sequence of atrial depolarization



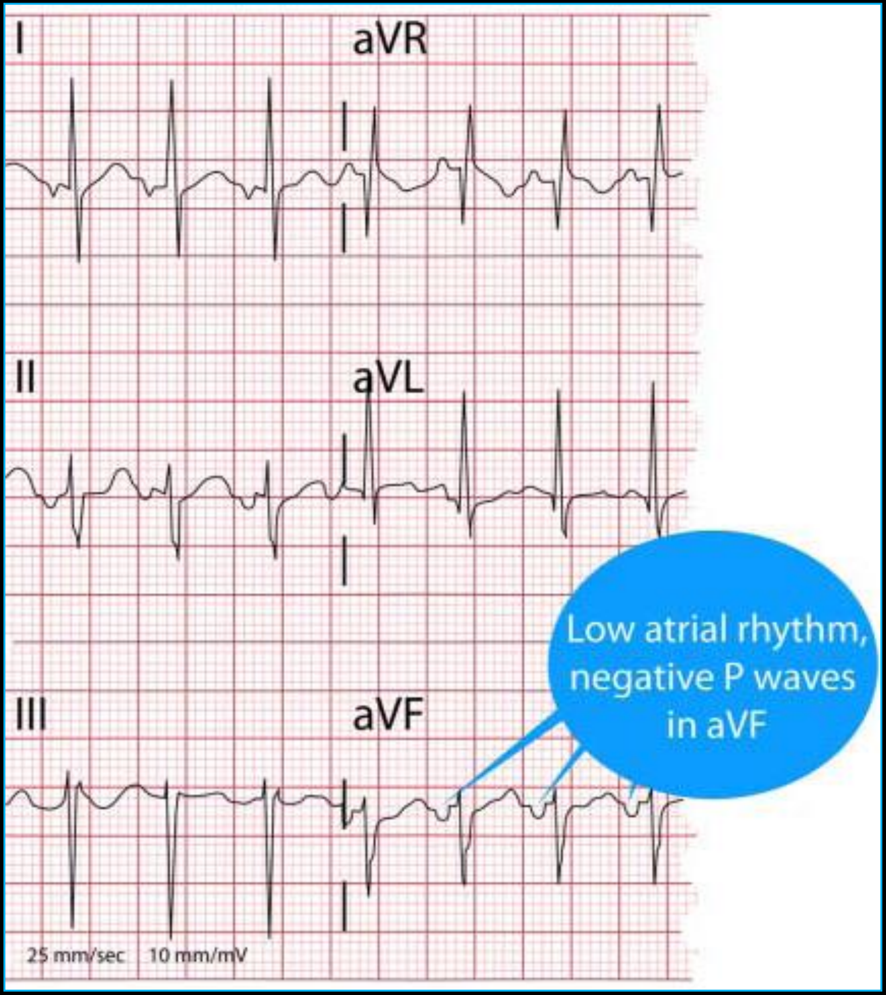
P wave axis

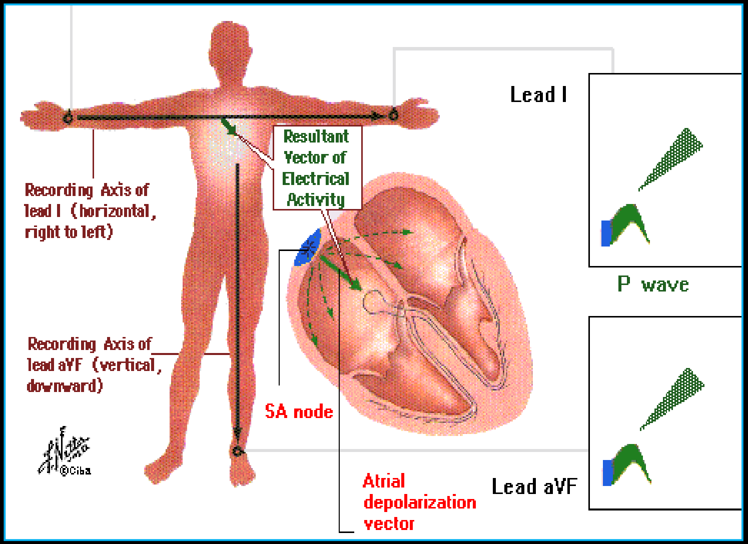
- Atrial depolarization occurs from SA node
  - Wave passes right to left, top to bottom
  - Positive deflections in leads I (right to left) and aVF (top to bottom)
  - Normal P wave axis = 0-90 degrees
- Abnormal axis implies ectopic pacemaker
  - Coronary sinus or “low right atrial” rhythm is common <u>benign</u> finding, especially in teens
  - Positive in lead I, negative in aVF

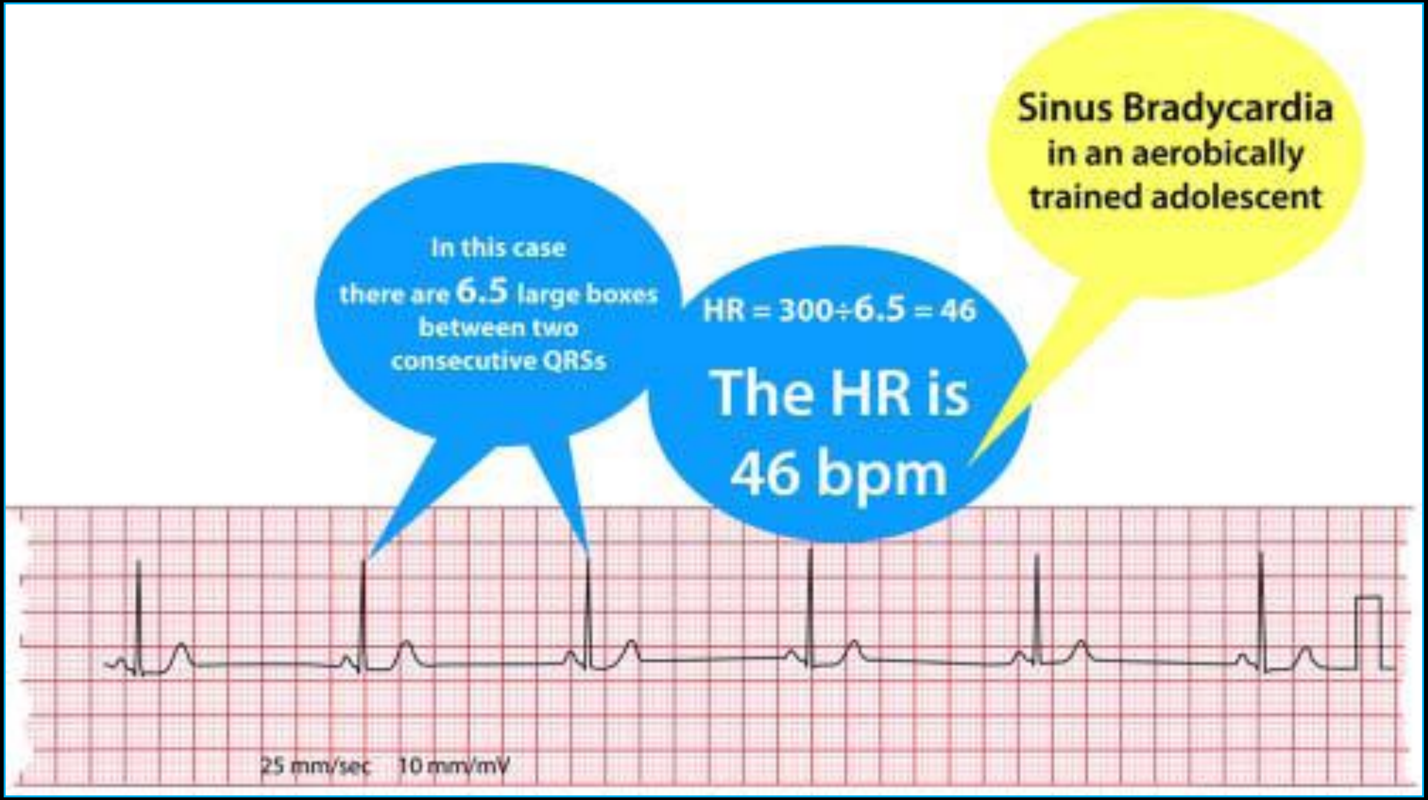
It is a sinus rhythm.. why ?

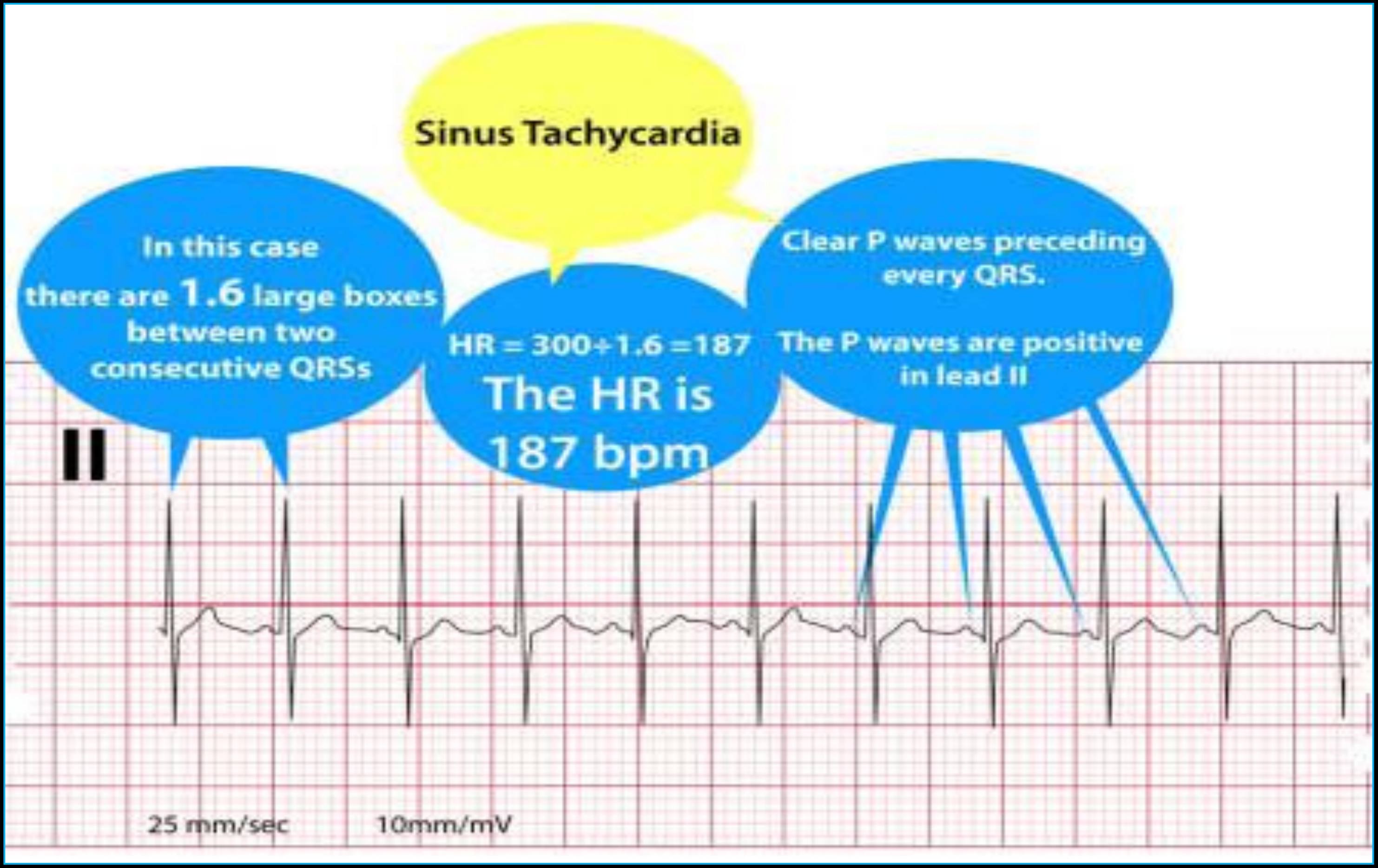


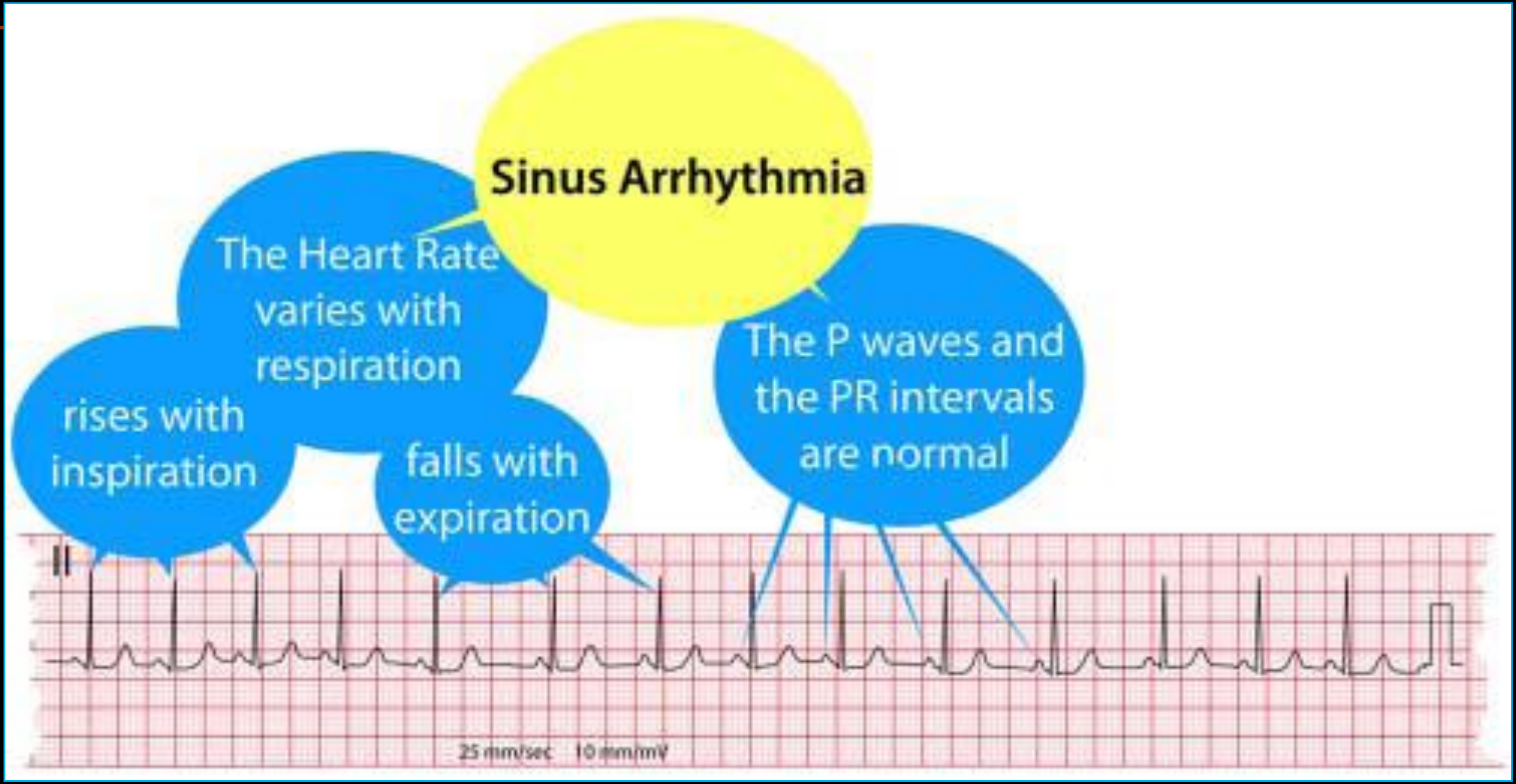
It is a non-sinus rhythm






Sinus Bradycardia
in an aerobically
trained adolescent
In this case
there are 6.5 large boxes
between two
consecutive QRSs
HR = 300÷6.5 = 46
The HR is
46 bpm
25 mm/sec
10 mm/mV


Sinus Tachycardia
In this case there are 1.6 large boxes between two consecutive QRSs
HR = 300÷1.6 =187
The HR is 187 bpm
Clear P waves preceding every QRS.
The P waves are positive in lead II
II
25 mm/sec
10mm/mV



Sinus Arrhythmia
The Heart Rate varies with respiration
rises with inspiration
falls with expiration
The P waves and the PR intervals are normal
II
25 mm/sec 10 mm/mV

What is the underling rhythm ?

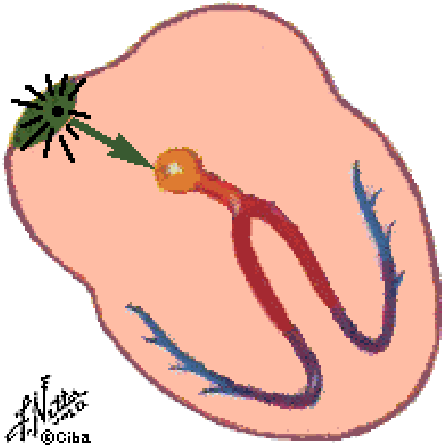
The 5 Requirements for Normal Sinus Rhythm :

- P wave before every QRS.
- QRS following every P wave.
- Normal P wave axis.
- Normal PR interval is NOT required.
- Sinus rate within normal range for age.

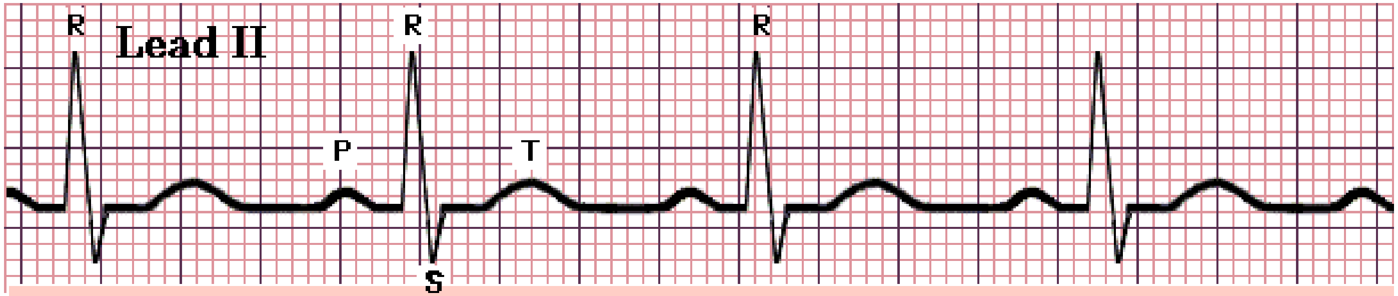
Normal Sinus Rhythm

A sinus origin is assumed if P waves are regular and upright in leads II, III, and aVF.*

If the heart rate is 60 to 100/minute, Normal Sinus Rhythm is present.



Impulses originate at SA node AT NORMAL RATE *



All complexes are evenly spaced; RR interval = 0.85 sec., rate = 60/0.85 = 70/minute *

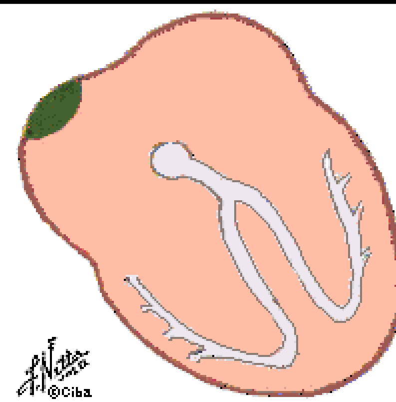
Supraventricular or ventricular rhythm

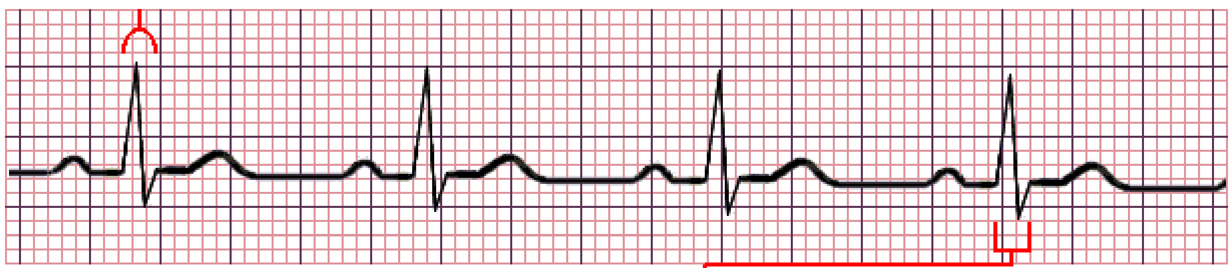
This is an example of a supraventricular rhythm with normal intraventricular conduction: QRS <0.10 * second (i.e., this is NOT a ventricular rhythm).

Differentiation between supraventricular and ventricular rhythms is made on the basis of the duration (width) of the QRS complex.*

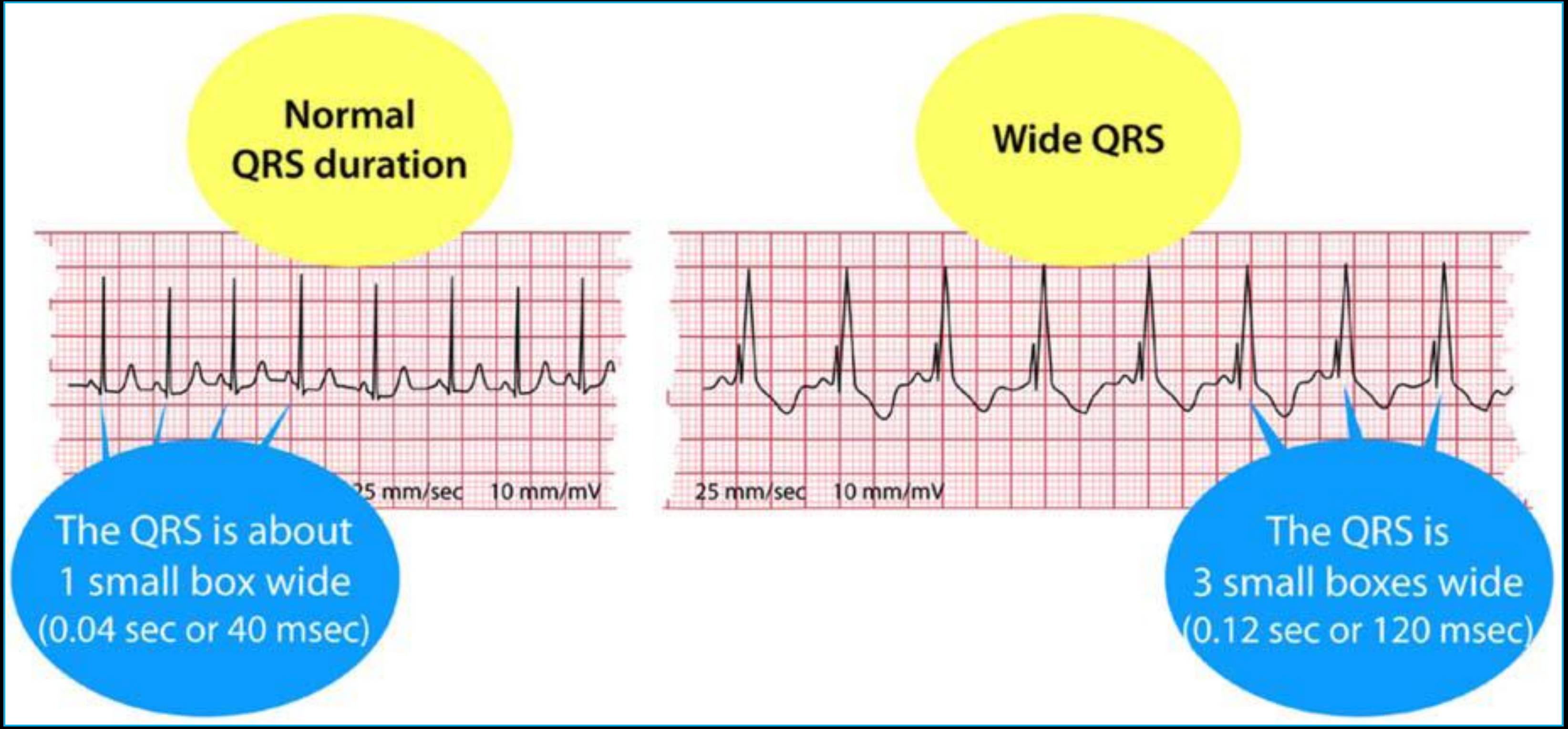
Supraventricular origin of impulse may be sinus,* atrial,* or junctional.*

Impulse travels rapidly along conduction system.*



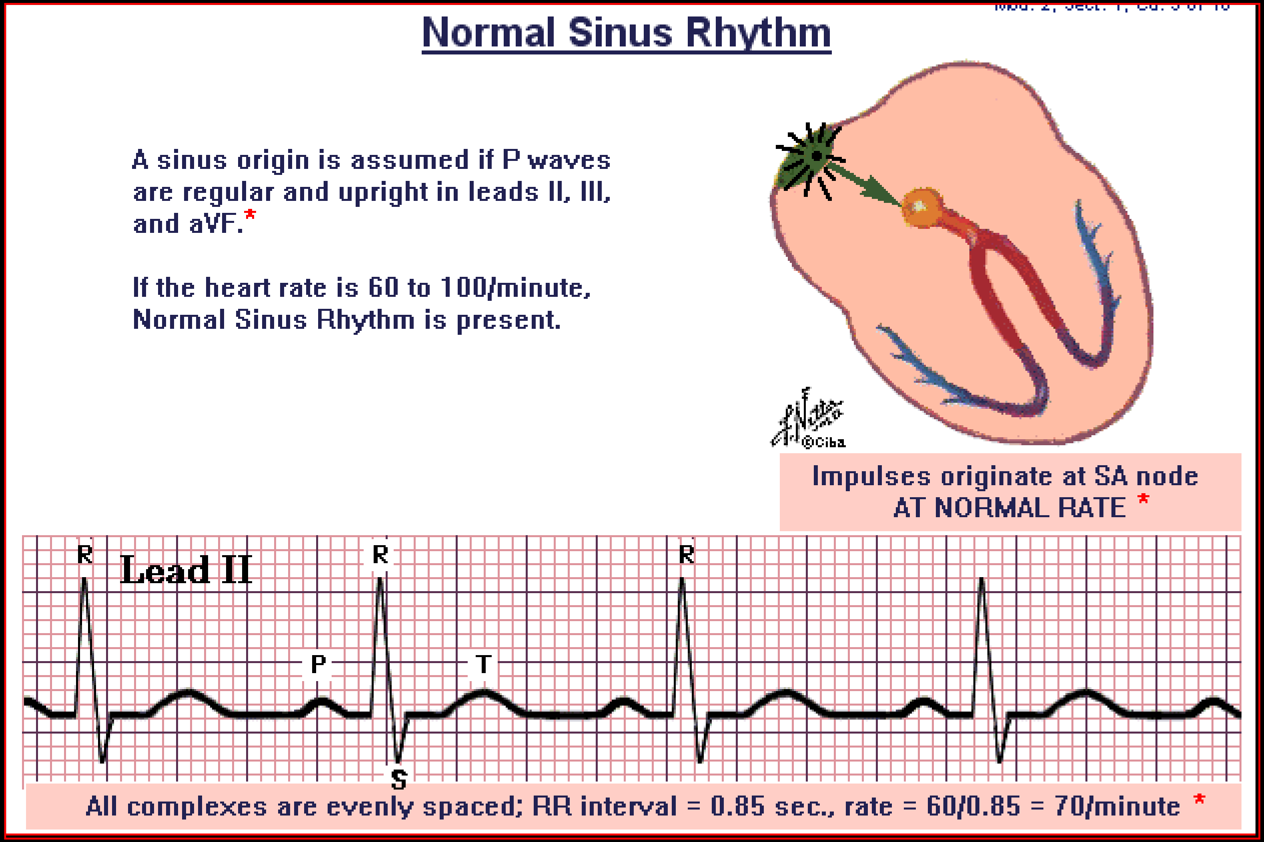


A supraventricular rhythm characterized by brief (narrow) QRS duration (<2.5 small boxes)



Normal
QRS duration
Wide QRS
25 mm/sec
10 mm/mV
25 mm/sec
10 mm/mV
The QRS is about
1 small box wide
(0.04 sec or 40 msec)
The QRS is
3 small boxes wide
(0.12 sec or 120 msec)

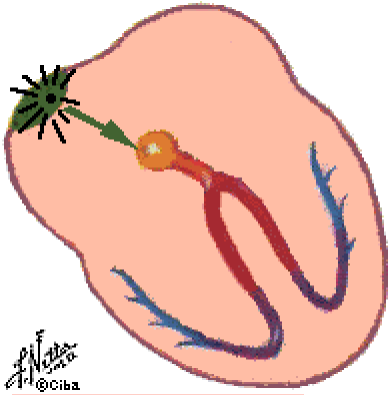
Supraventricular rhythms


Normal Sinus Rhythm
A sinus origin is assumed if P waves are regular and upright in leads II, III, and aVF.*
If the heart rate is 60 to 100/minute, Normal Sinus Rhythm is present.
©Ciba
Impulses originate at SA node AT NORMAL RATE *
Lead II
R
R
R
P
T
S
All complexes are evenly spaced; RR interval = 0.85 sec., rate = 60/0.85 = 70/minute *

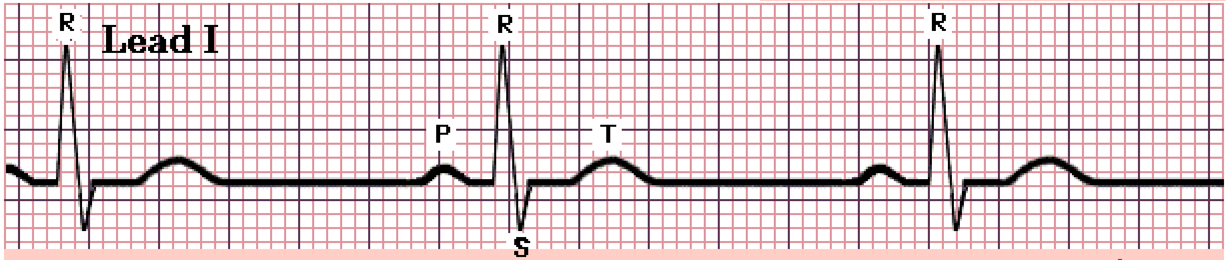
Sinus Bradycardia

If the rate is less than 60/minute, Sinus Bradycardia is present.

This may be caused by increased vagal or parasympathetic tone, or occur in the acute stages of myocardial infarction, particularly diaphragmatic infarction.



Impulses originate at SA node AT SLOW RATE *

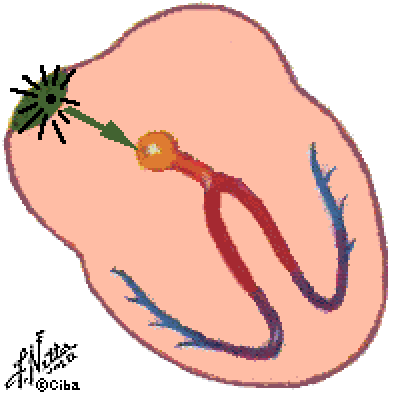


All complexes are evenly spaced; RR interval = 1.24 sec., rate = 48/minute *

Sinus Tachycardia

If the rate is greater than 100/minute, Sinus Tachycardia is present.

Sinus Tachycardia is most often a physiological response to exercise, fever, pain, fear, or other stresses, but may also be a clue to occult congestive heart failure or other cardiac decompensation.



Impulses originate at SA node AT RAPID RATE *

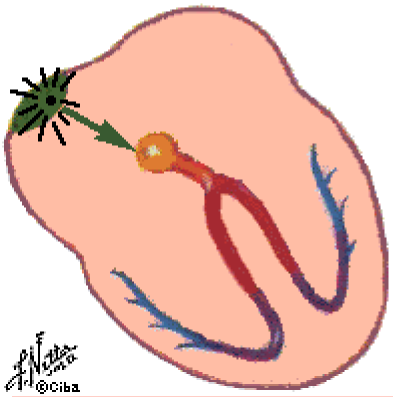
All complexes are evenly spaced; RR interval = 0.54 sec., rate = 111/minute *

Sinus Arrhythmia *

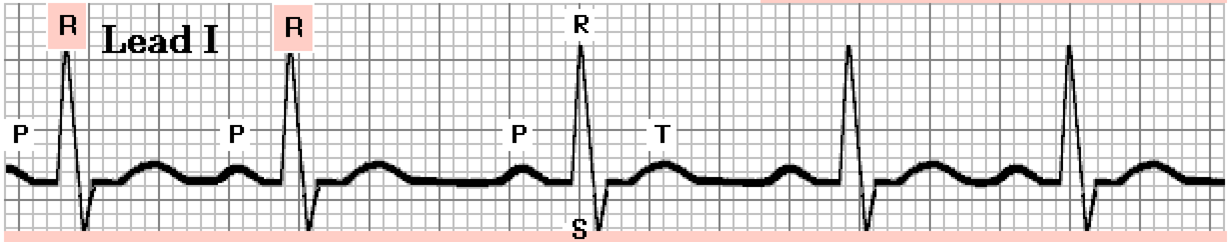
If all P waves are identical and upright in leads II, III, and aVF, but rhythmically irregular, further measure- ment is necessary.

If the longest PP or RR interval exceeds the short- est such interval by 0.16 second (i.e., four small boxes) or more, Sinus Arrhythmia is diagnosed.

In the tracing shown, the interval between the first and second P (or R) waves is 16 small boxes, or 0.64 second.* The interval between the second and third P (or R) waves is 21 small boxes, or 0.84 second. The difference exceeds 0.16 second, and thus Sinus Arrhythmia is diagnosed.



Impulses originate at SA node
AT VARYING RATE *

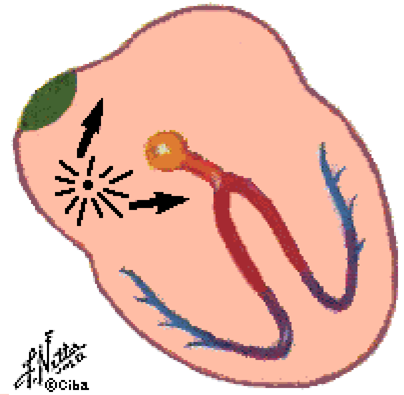


All complexes are normal but rhythmically irregular. Longest PP or RR interval exceeds shortest by 0.16 second or more.

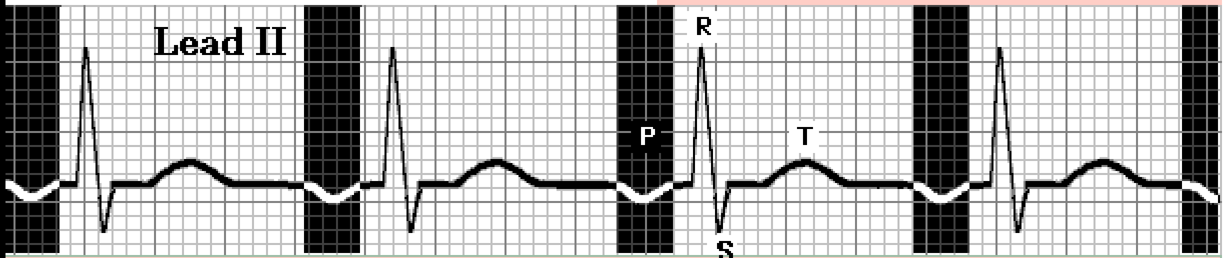
Nonsinus Atrial (Coronary Sinus) Rhythm

If all P waves are identical and regular but inverted in leads II, III, and aVF, the P wave axis is highly abnormal, implying an origin other than the SA node, located in the upper right corner of the atrium.

This is a Nonsinus Atrial Rhythm.*



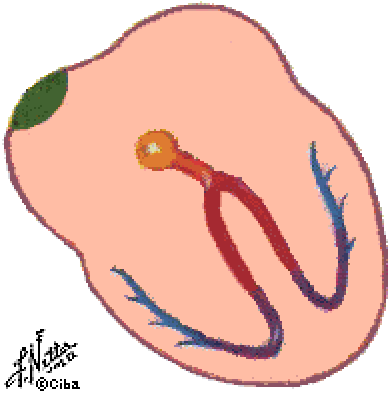
Impulses originate low in atrium; travel RETROGRADE as well as DISTALLY *



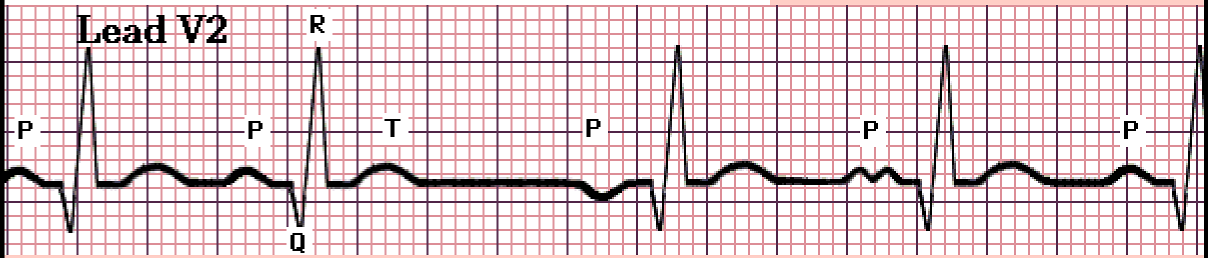
P waves inverted in leads II, III, and aVF

Wandering atrial pacemaker

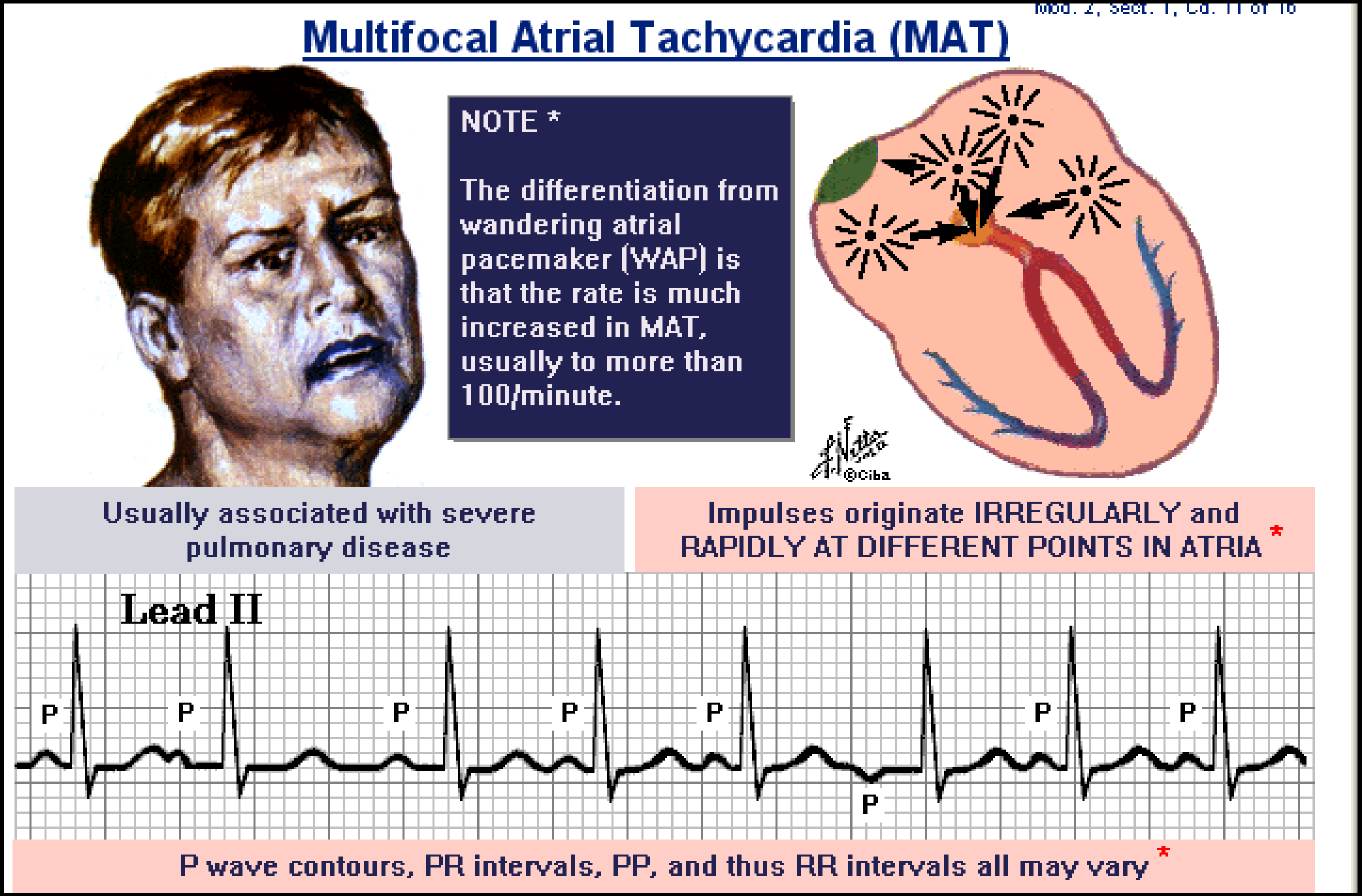
If the contour or shape of P waves varies from beat to beat in a single lead, often associated with variation of the PR interval and the PP, and thus the RR intervals, it seems likely that the site of atrial depolarization is varying (i.e., Wandering Atrial Pacemaker). *



Impulses originate from VARYING POINTS IN ATRIA *



Variation in P wave contour, PR interval, PP, and thus RR intervals *

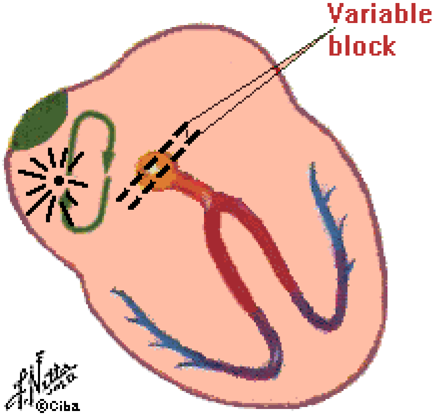


Mod. 2, Sect. 1, Cd. 11 of 16
Multifocal Atrial Tachycardia (MAT)
NOTE *
The differentiation from wandering atrial pacemaker (WAP) is that the rate is much increased in MAT, usually to more than 100/minute.
©Ciba
Usually associated with severe pulmonary disease
Impulses originate IRREGULARLY and RAPIDLY AT DIFFERENT POINTS IN ATRIA *
Lead II
P
P
P
P
P
P
P
P
P wave contours, PR intervals, PP, and thus RR intervals all may vary *

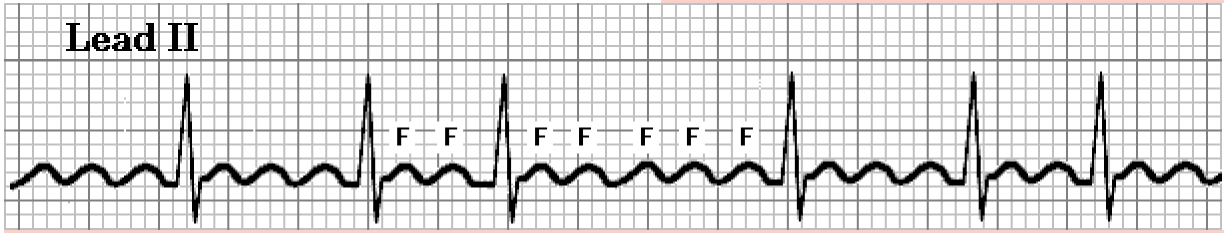
Atrial Flutter

Impulse travels in circular course in atria, setting up regular, rapid (220 to 300/minute) flutter (F) waves without any isoelectric baseline.*

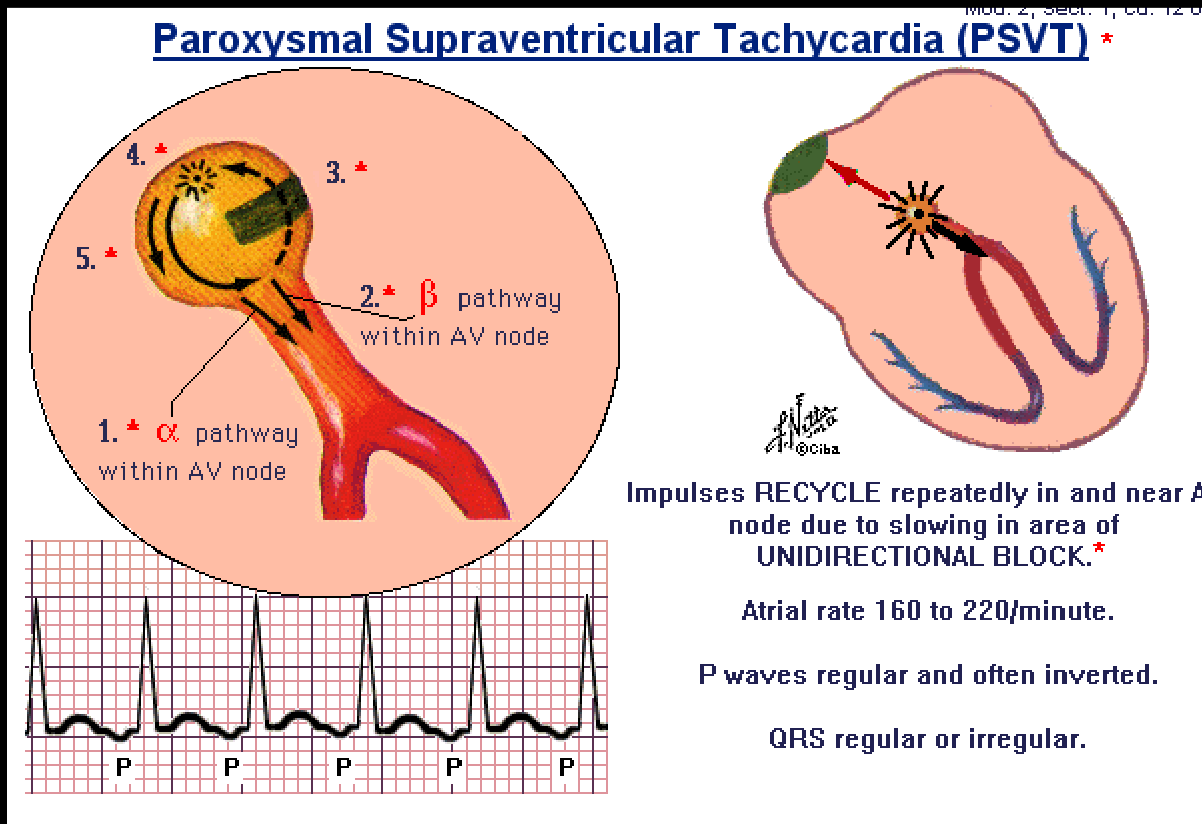
Some degree of AV block is usually present.*

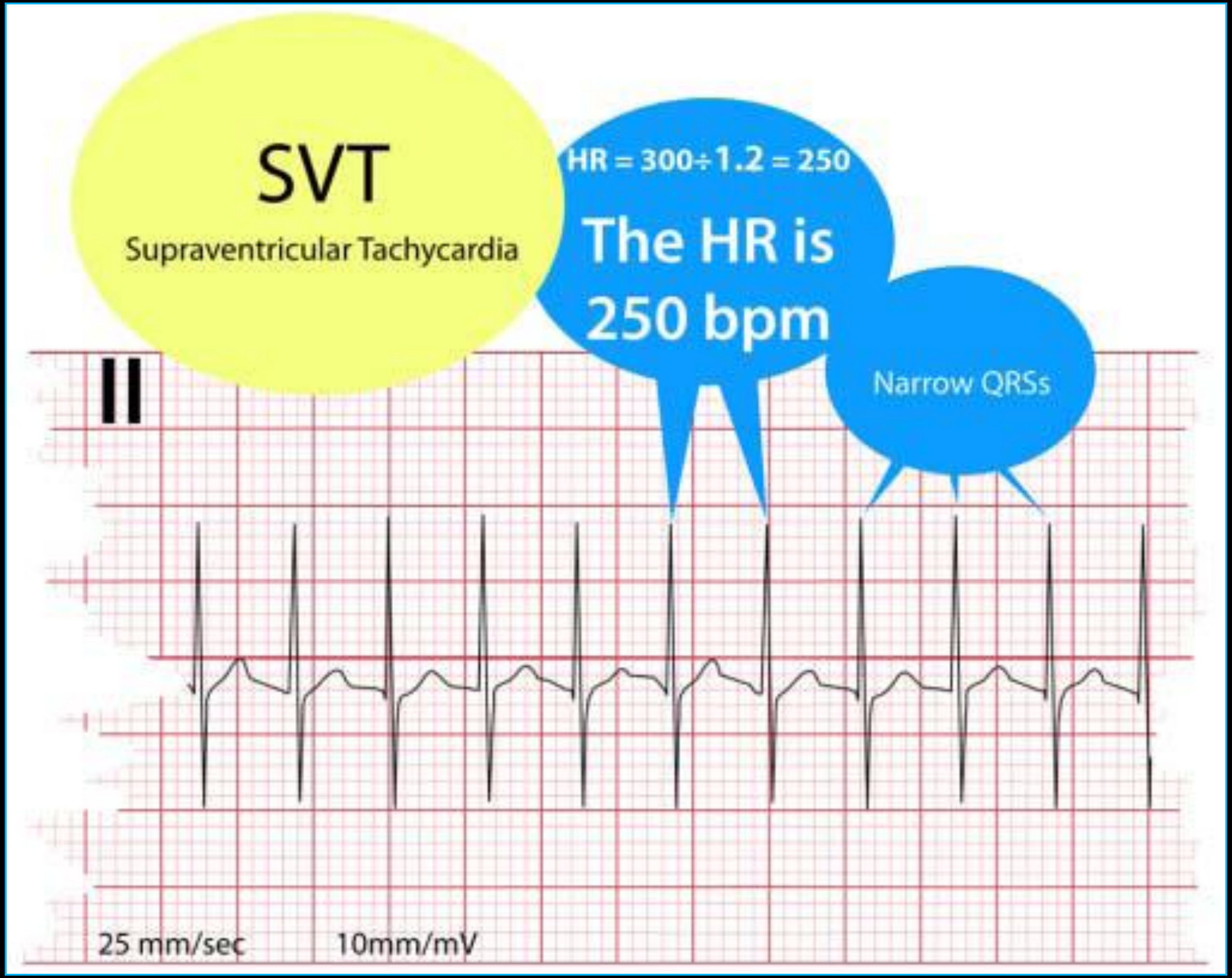


*



Rapid flutter (F) waves. Ventricular rate (QRS) regular or irregular and slower (depending on degree of block).

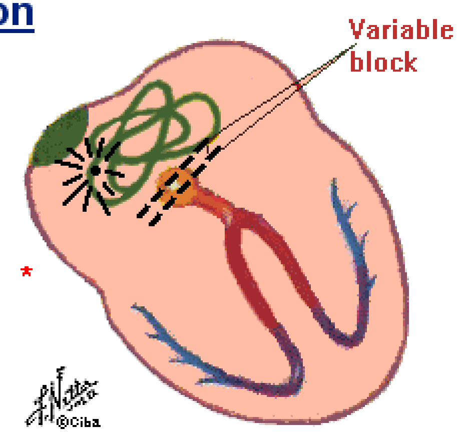

Mod. 2, Sect. 1, Cd. 12 of
Paroxysmal Supraventricular Tachycardia (PSVT) *
4. *
3. *
5. *
2.* β pathway
within AV node
1. * α pathway
within AV node
P
P
P
P
P
©Ciba
Impulses RECYCLE repeatedly in and near AV
node due to slowing in area of
UNIDIRECTIONAL BLOCK.*
Atrial rate 160 to 220/minute.
P waves regular and often inverted.
QRS regular or irregular.


SVT
Supraventricular Tachycardia
HR = 300÷1.2 = 250
The HR is 250 bpm
Narrow QRSs
II
25 mm/sec
10mm/mV

Atrial Fibrillation

Impulses take chaotic, random pathways in the atria.

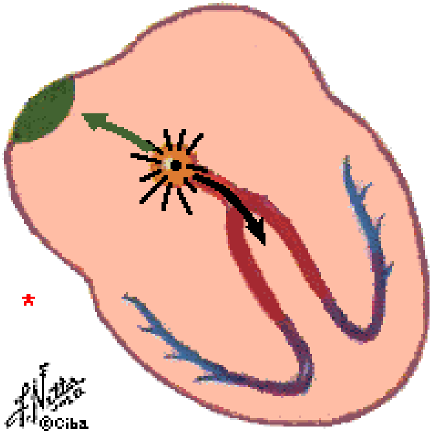
There is no organized electric activity (and hence no effective pumping action) in the atria.



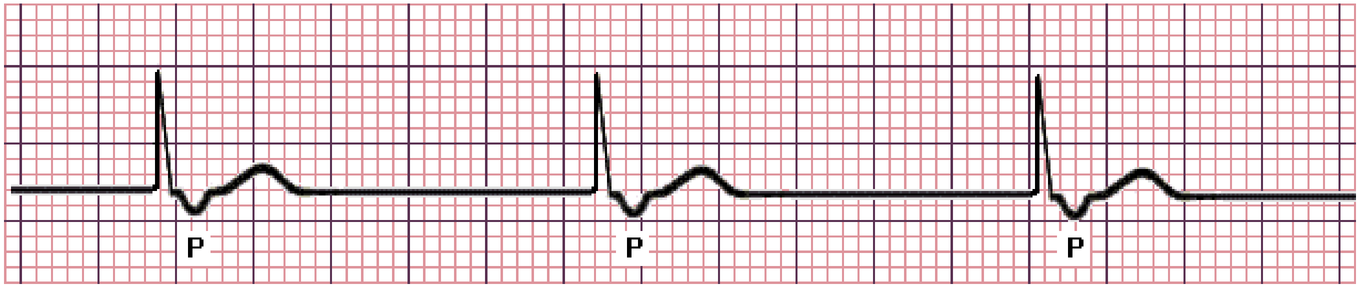
Baseline coarsely* or finely* irregular; P wave absent. Ventricular response (QRS) irregular, slow, or rapid.*

Junctional Rhythm

Impulses originate in AV node with RETROGRADE and ANTEGRADE transmission.



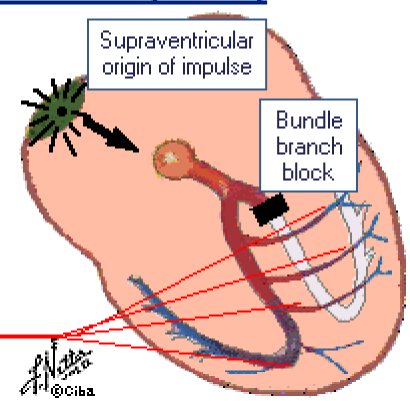
P wave, often inverted, may be buried in QRS or follow QRS. Rate slow. QRS narrow.



Intraventricular Conduction Defect (IVCD)

Intraventricular conduction defect (IVCD), including right or left bundle branch block, is a supraventricular rhythm.

IVCD has a wide QRS* complex which is characteristic of ventricular rhythms, but the impulse is of supraventricular origin.

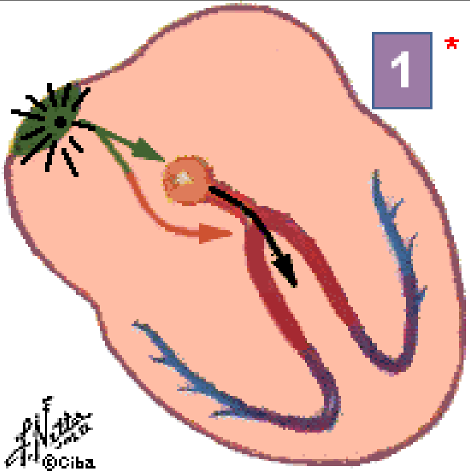


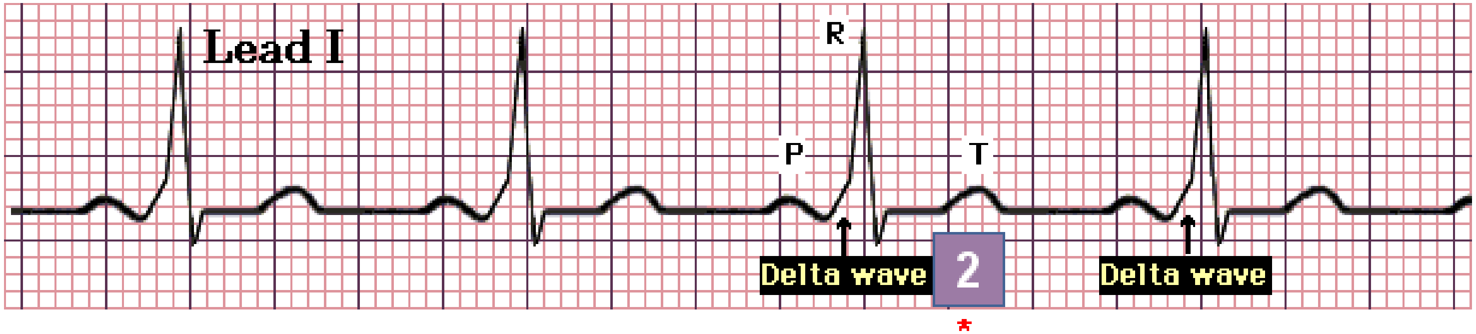
Conduction below block occurs by slow spread from uninvolved side *

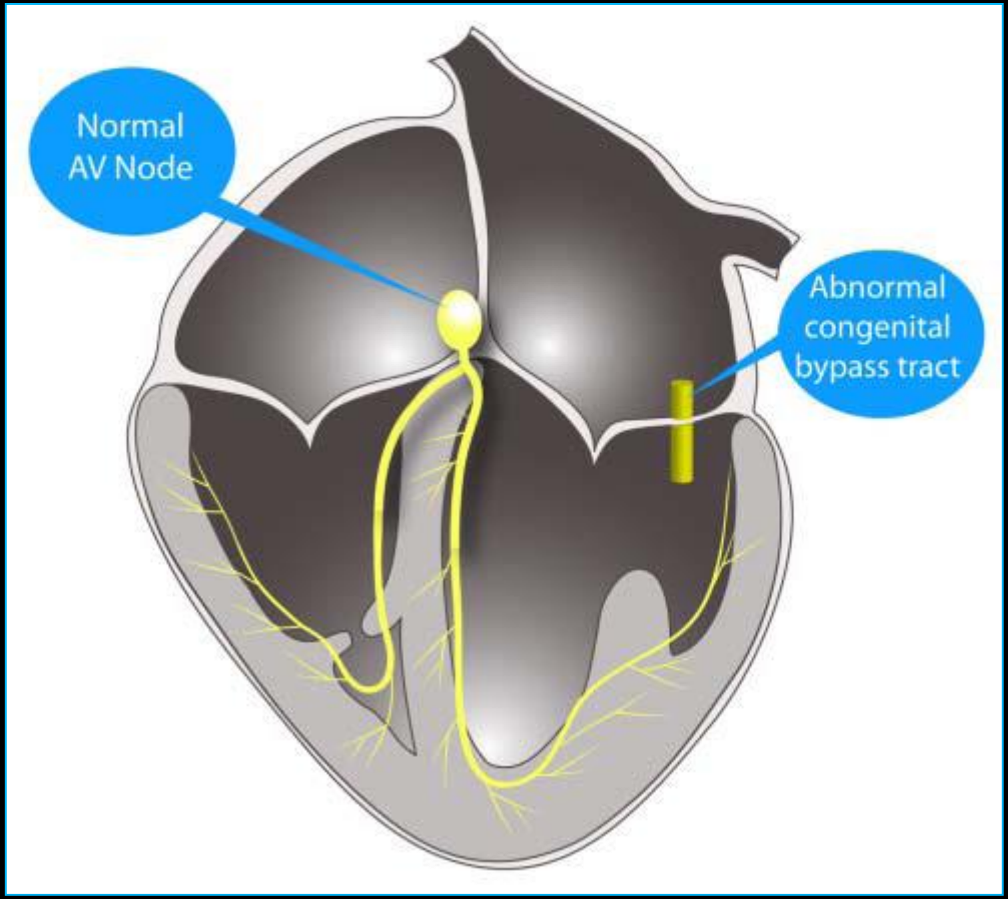
Wide QRS (>2.5 small boxes)*, often notched, preceded by P wave with normal PR interval

Wolff-Parkinson-White syndrome

Wolff-Parkinson-White syndrome is a supraventricular rhythm which has a wide QRS complex because of preexcitation.






Normal
AV Node
Abnormal
congenital
bypass tract

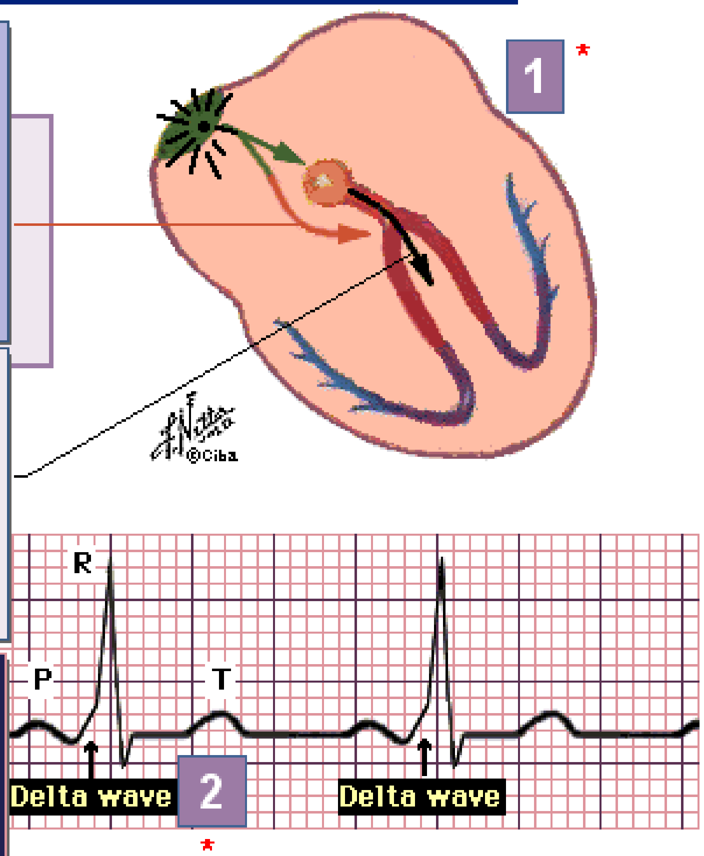
Wolff-Parkinson-White syndrome

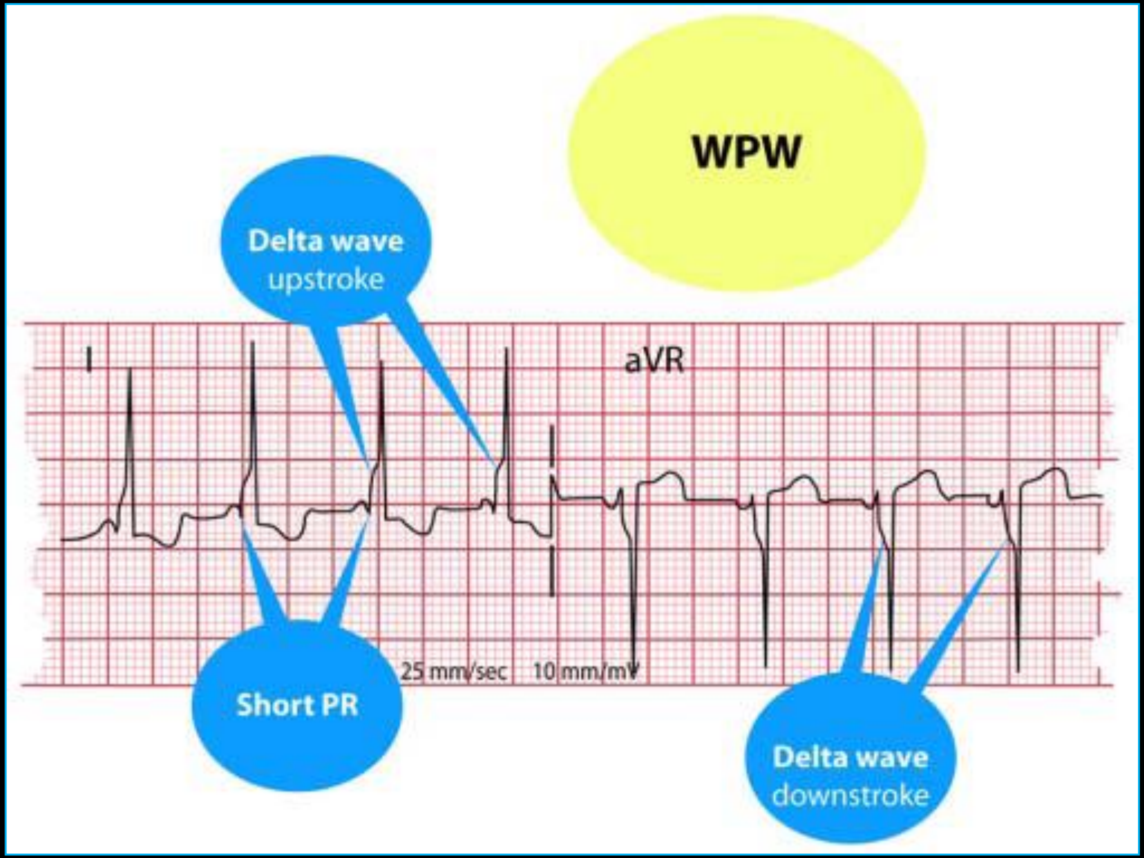
NOTE 1 *
Impulses originate at SA node and preexcite peripheral conduction system and ventricular muscle via bundle of Kent without delay at AV node, thus producing the early slurred upstroke (the delta wave) of the QRS complex. (In type B, impulses may pass via posterior accessory bundle.)

NOTE 1 (cont.) *
After normal delay at AV node, impulses also arrive at ventricles via normal route to continue depolarization. Thus, the QRS tends to be prolonged, not because it lasted longer, but because it started earlier as a result of preexcitation.

NOTE 2 *

P wave is immediately followed by short delta wave, producing slurred upstroke on wide QRS with short or no PR interval.





WPW
Delta wave upstroke
I
aVR
Short PR
25 mm/sec
10 mm/mV
Delta wave downstroke

How would you classify this ECG tracing?

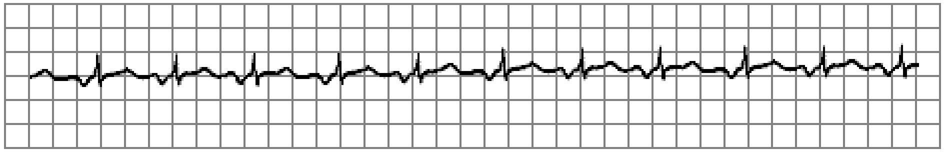
Lead II

1. Normal rhythm
2. Supraventricular arrhythmia
3. Ventricular arrhythmia
4. Conduction defect
5. Atrial premature contraction

Self-Test 3

Supraventricular Rhythms

Good.

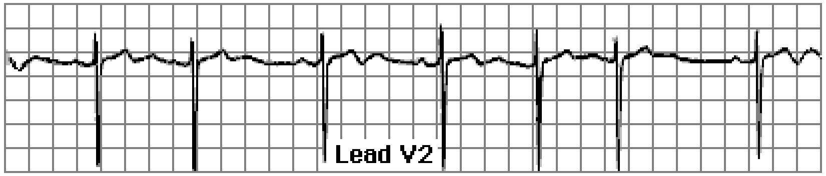


Lead II

1. Normal rhythm
2. ✓ Supraventricular arrhythmia
3. Ventricular arrhythmia
4. Conduction defect
5. Atrial premature contraction

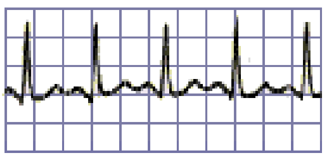
a. Sinus tachycardia
b. Sinus bradycardia
c. Sinus arrhythmia
d. **Nonsinus atrial rhythm**
e. Paroxysmal atrial tachycardia
f. Sinus arrest
g. Wandering atrial pacemaker
h. Atrial flutter
i. Atrial fibrillation

The following is a rhythm strip of lead V2. How would you classify this tracing? Use hints if you need to.

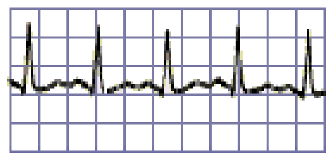


1. Sinus arrhythmia, because PP intervals vary
2. Multifocal atrial tachycardia, because of several P wave shapes
3. Normal sinus rhythm, because rate is <100/minute
4. Nonsinus atrial rhythm
5. Wandering atrial pacemaker, because of (1) & (2) and more

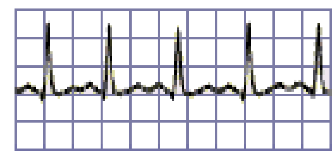
The following portions of a tracing indicate that SINUS TACHYCARDIA is present. Click the statement below that best explains why this is true. Use hints if you need to.



II



III

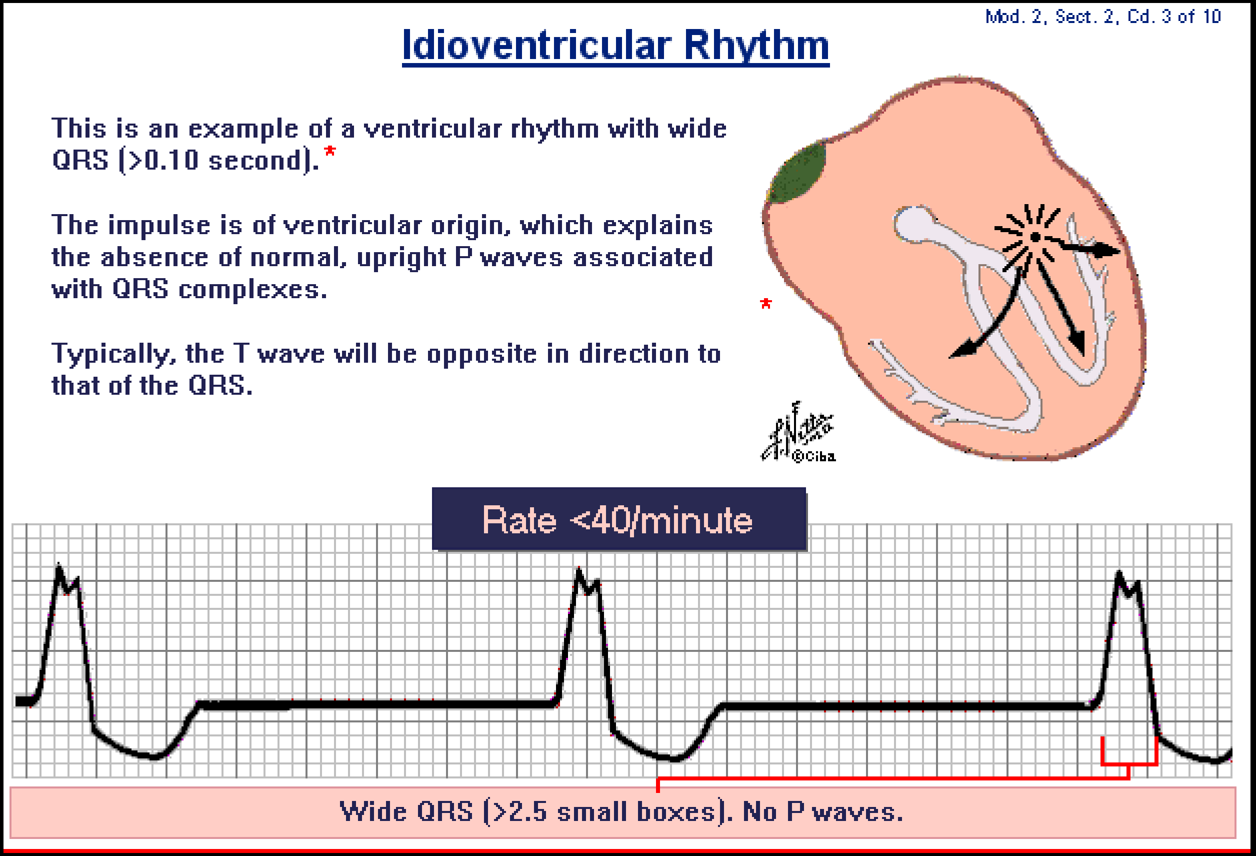


aVF

1. All complexes normal, evenly spaced, rate <60/minute
2. Impulses originate at SA node at varying rate
3. P waves are regular and upright in leads II, III, and aVF
4. All complexes normal, evenly spaced, rate >100/minute
5. All complexes normal, unevenly spaced, rate >100/minute

Ventricular rhythms

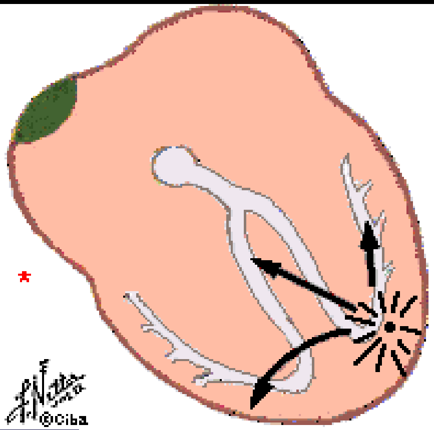
Idioventricular rhythm

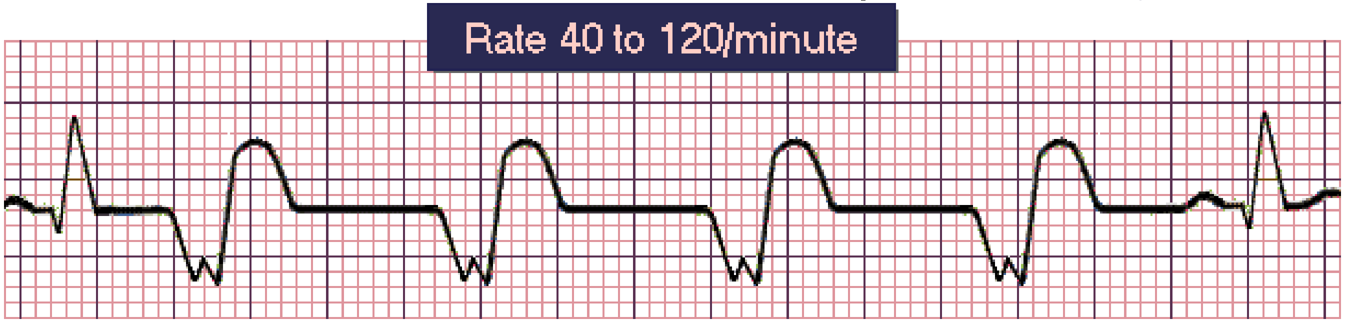


Accelerated Idioventricular rhythm

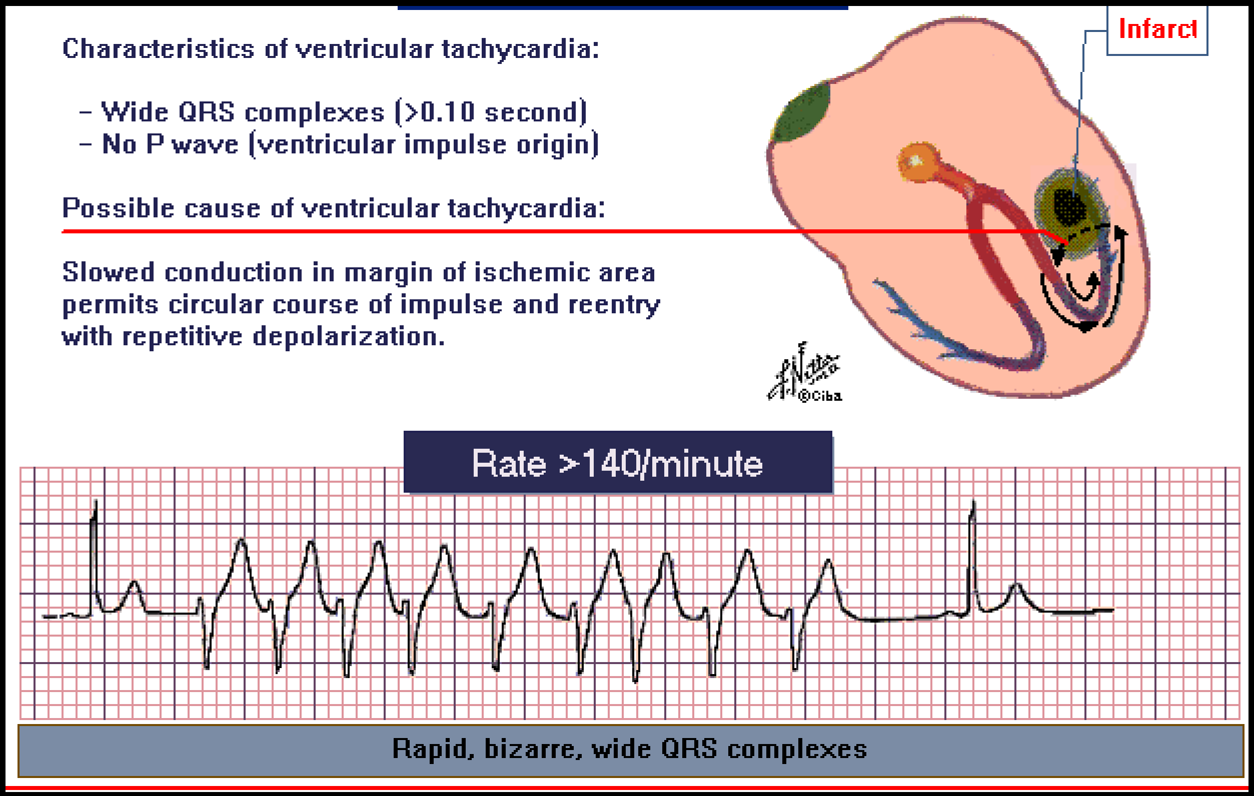
This is a ventricular rhythm characterized by wide QRS complexes (>0.10 second), and an absence of normal, upright P waves regularly preceding (i.e., related to) the QRS complex.

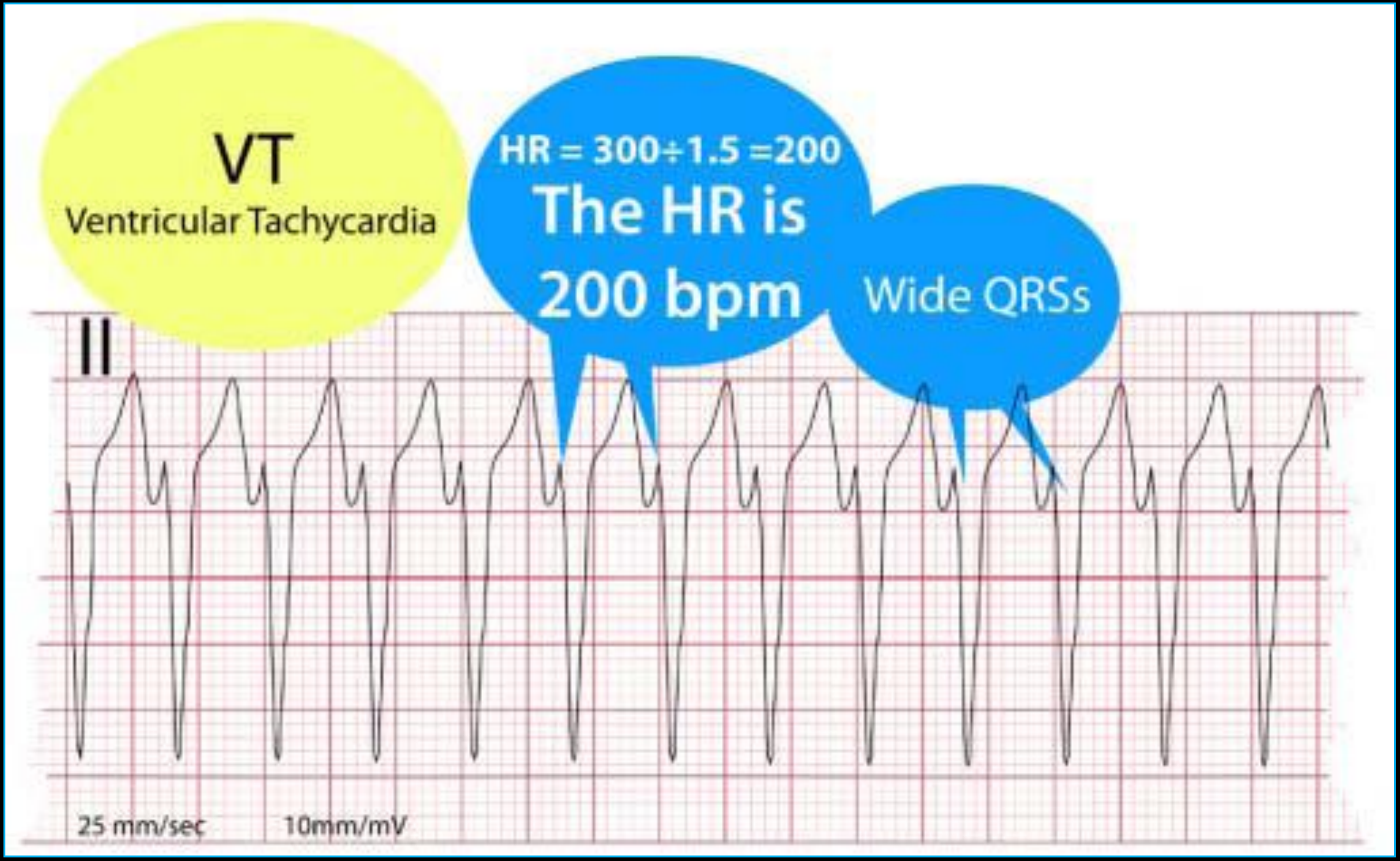
With its wide,* bizarre complexes, it can resemble, but is less dangerous than ventricular tachycardia (covered on the next card).



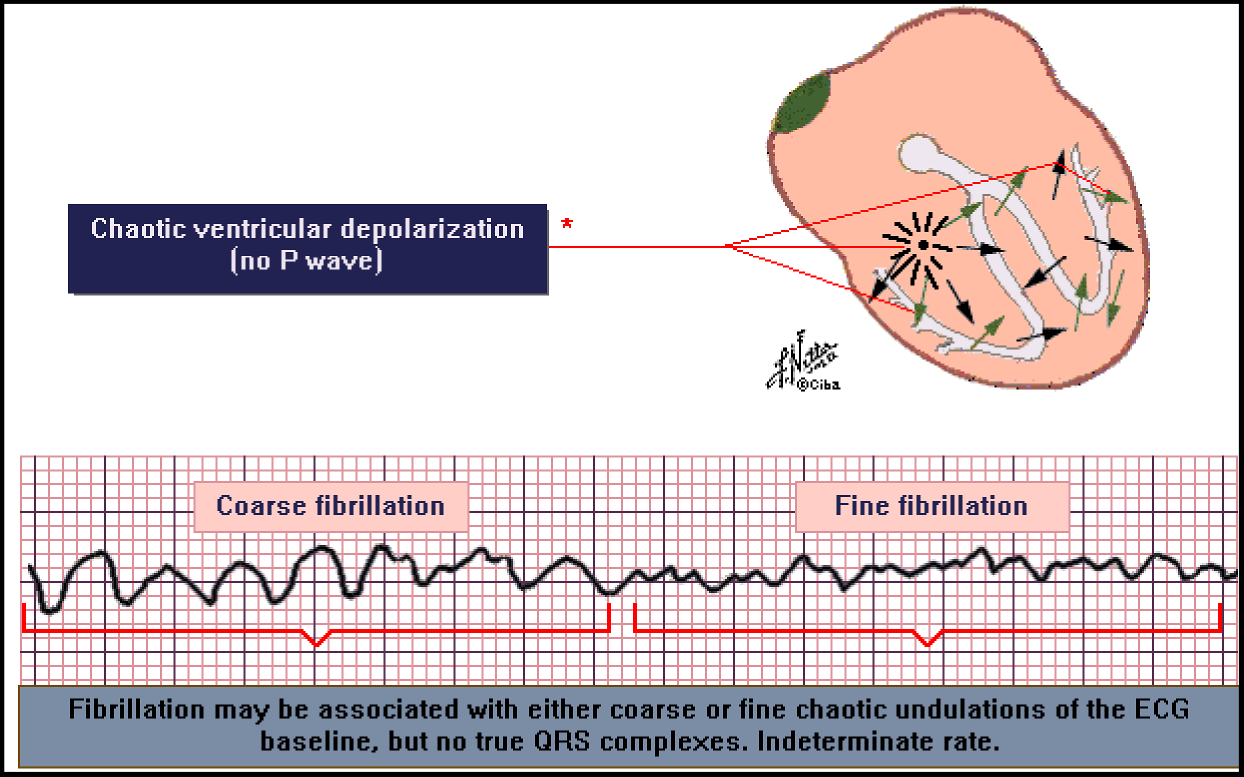


Ventricular tachycardia

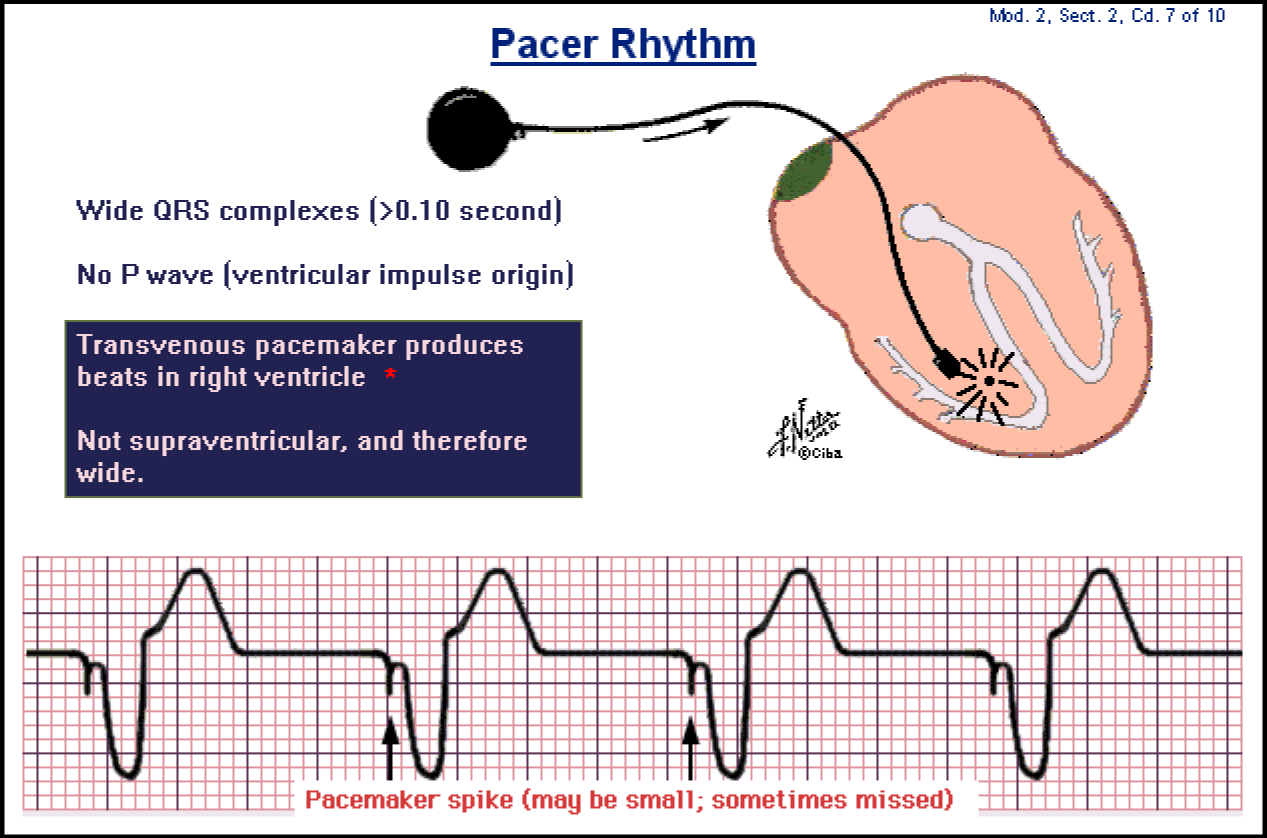



VT
Ventricular Tachycardia
HR = 300÷1.5 =200
The HR is
200 bpm
Wide QRSs
II
25 mm/sec
10mm/mV

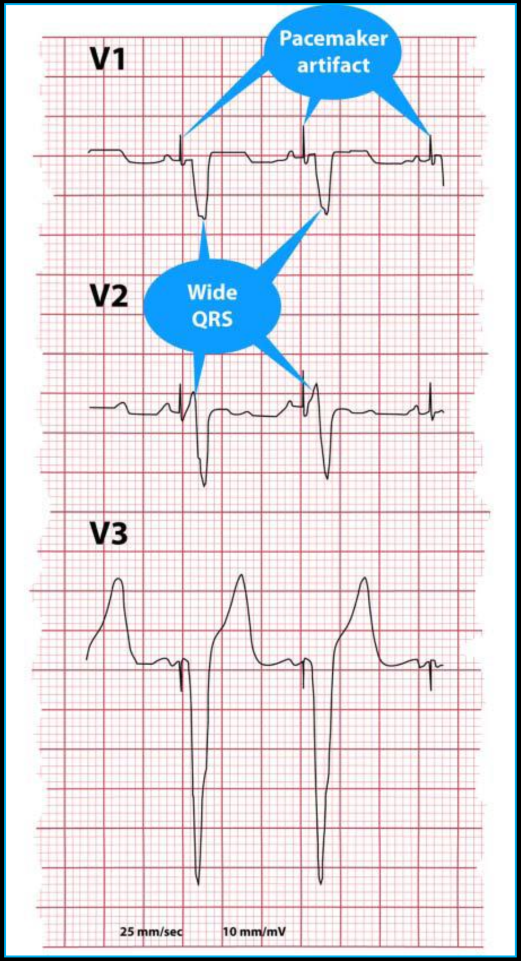
Ventricular fibrillation



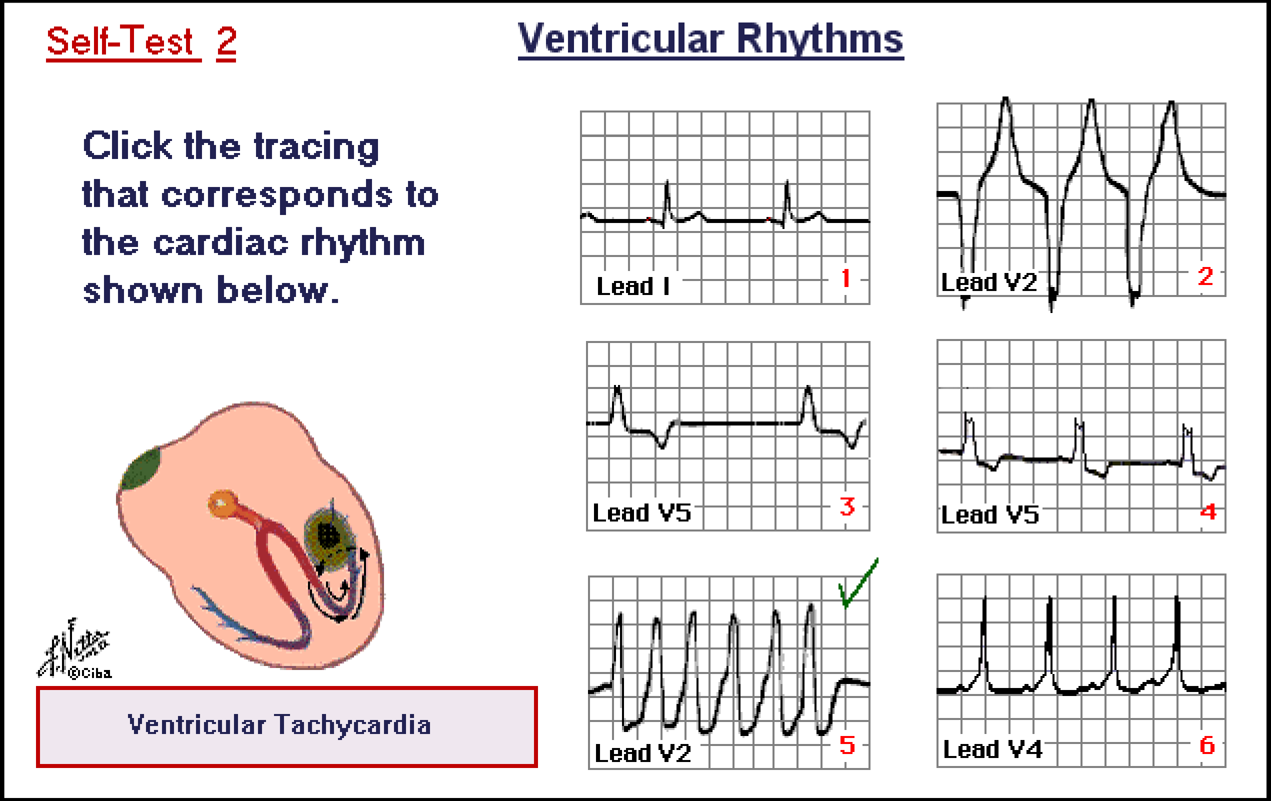
Pacemaker rhythm



Pacemaker rhythm

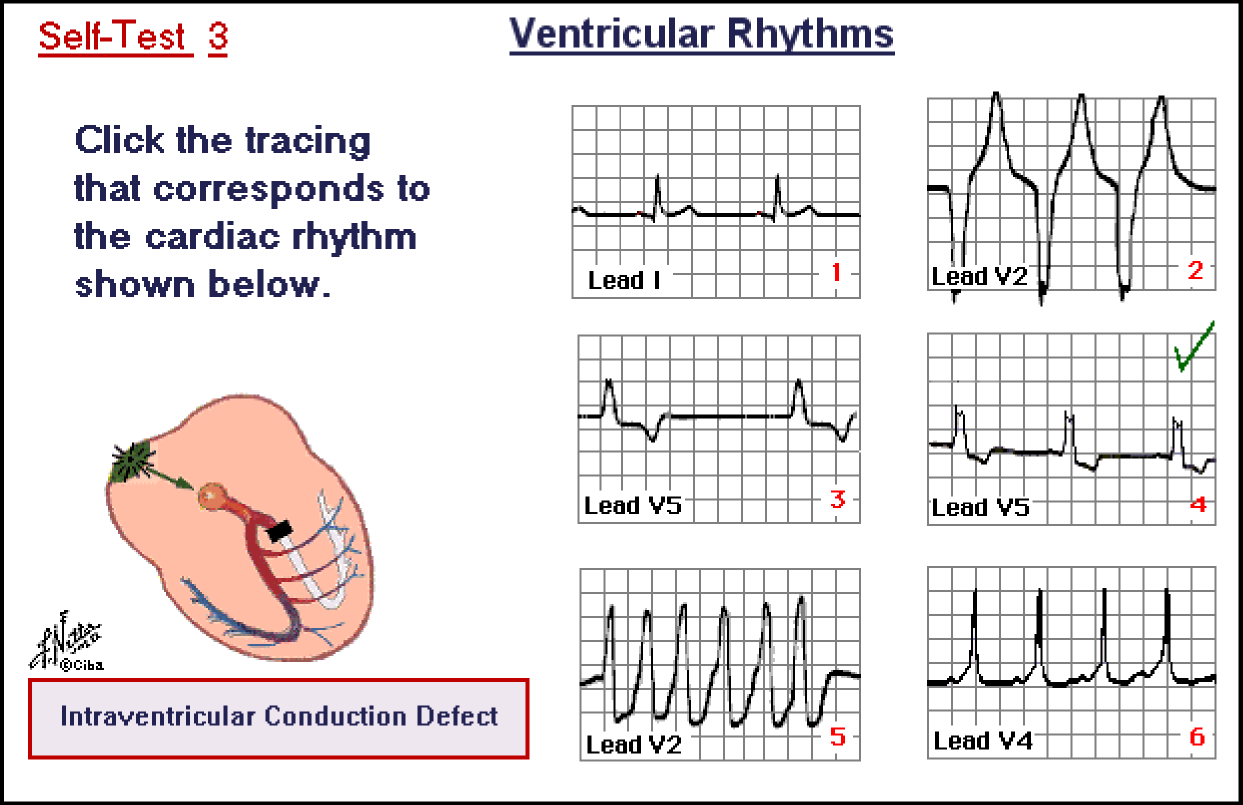


Self tests

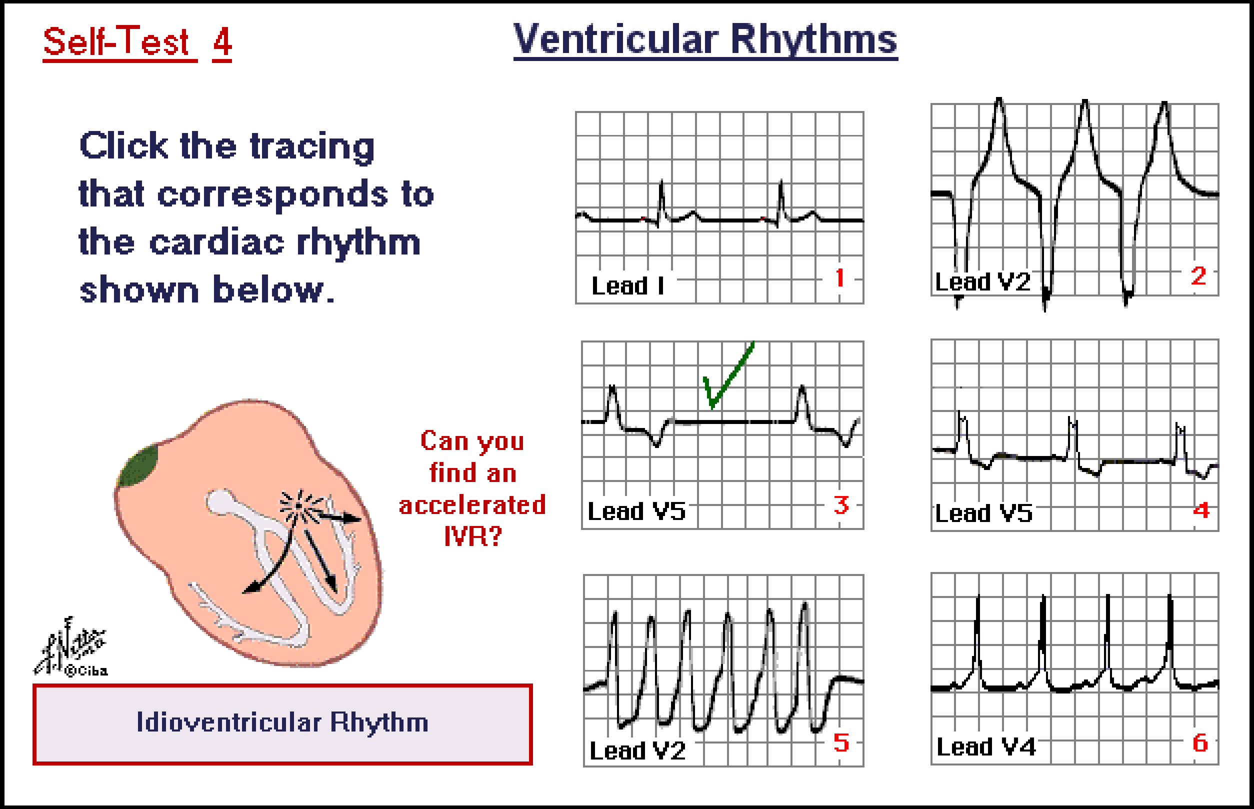


Self-Test 2
Ventricular Rhythms
Click the tracing that corresponds to the cardiac rhythm shown below.
Lead I
1
Lead V2
2
Lead V5
3
Lead V5
4
Lead V2
5
Lead V4
6
©Ciba
Ventricular Tachycardia

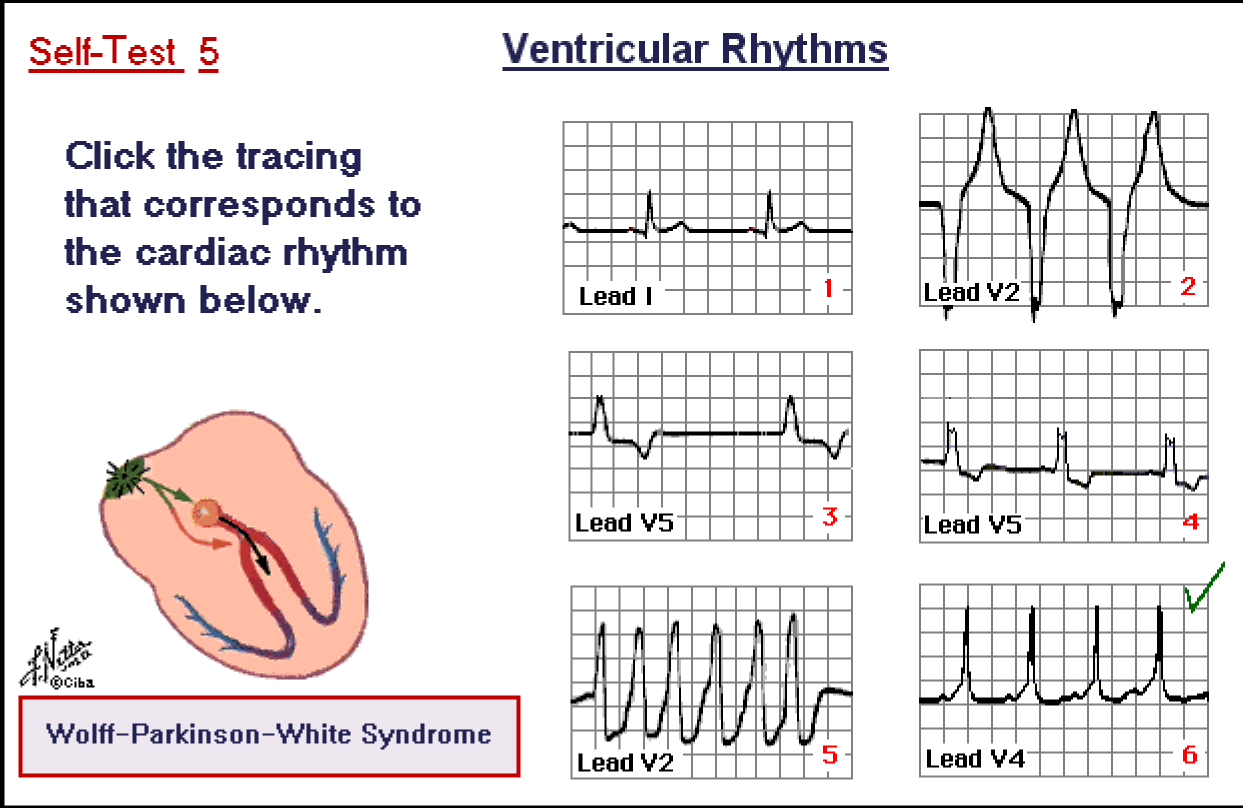
Self tests


Self-Test 3
Ventricular Rhythms
Click the tracing that corresponds to the cardiac rhythm shown below.
Lead I
1
Lead V2
2
Lead V5
3
Lead V5
4
Lead V2
5
Lead V4
6
©Ciba
Intraventricular Conduction Defect

Self tests

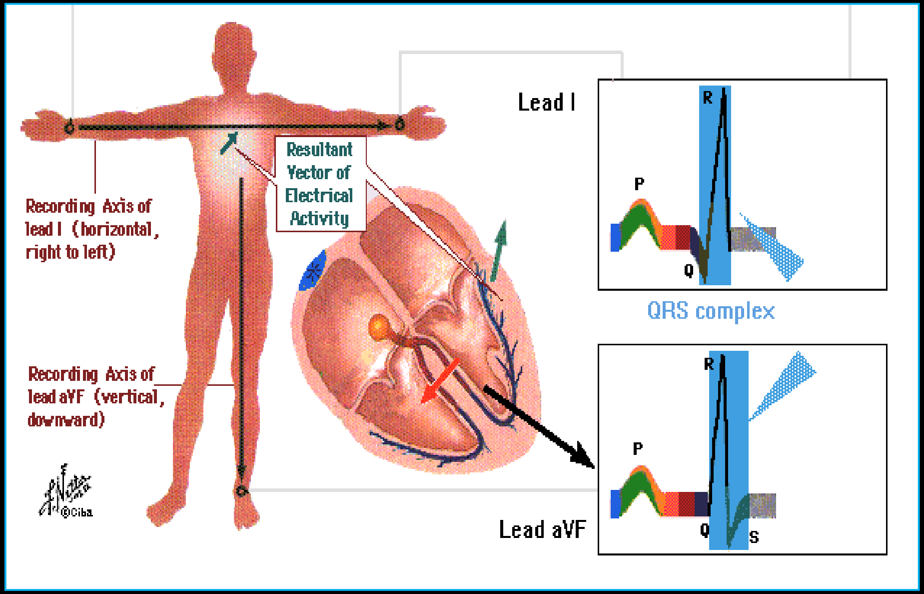

Self-Test 4
Ventricular Rhythms
Click the tracing that corresponds to the cardiac rhythm shown below.
Lead I
1
Lead V2
2
Lead V5
3
Lead V5
4
Lead V2
5
Lead V4
6
Can you find an accelerated IVR?
©Ciba
Idioventricular Rhythm

Self tests

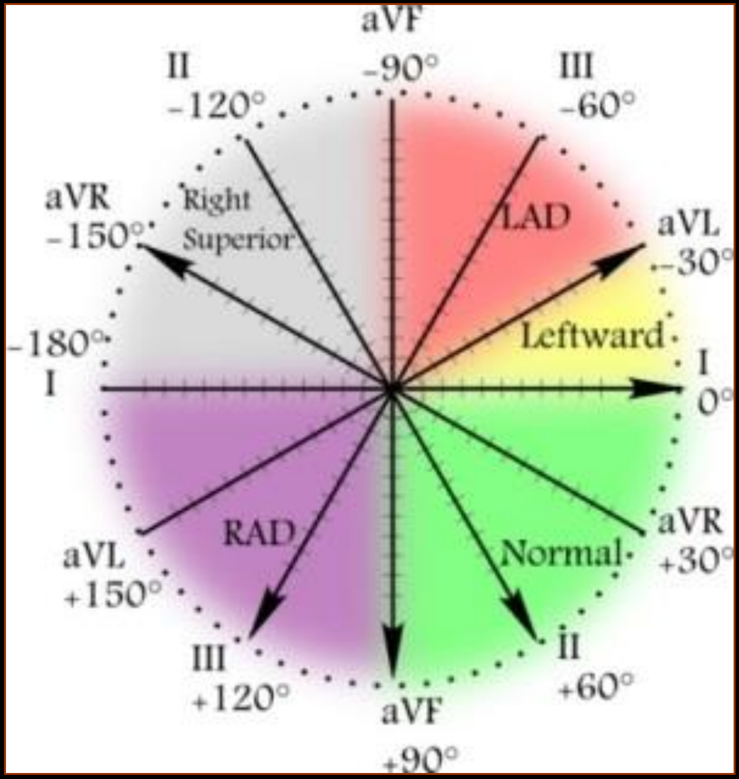


Self-Test 5
Ventricular Rhythms
Click the tracing that corresponds to the cardiac rhythm shown below.
Lead I
1
Lead V2
2
Lead V5
3
Lead V5
4
Lead V2
5
Lead V4
6
©Ciba
Wolff-Parkinson-White Syndrome

III- QRS Axis

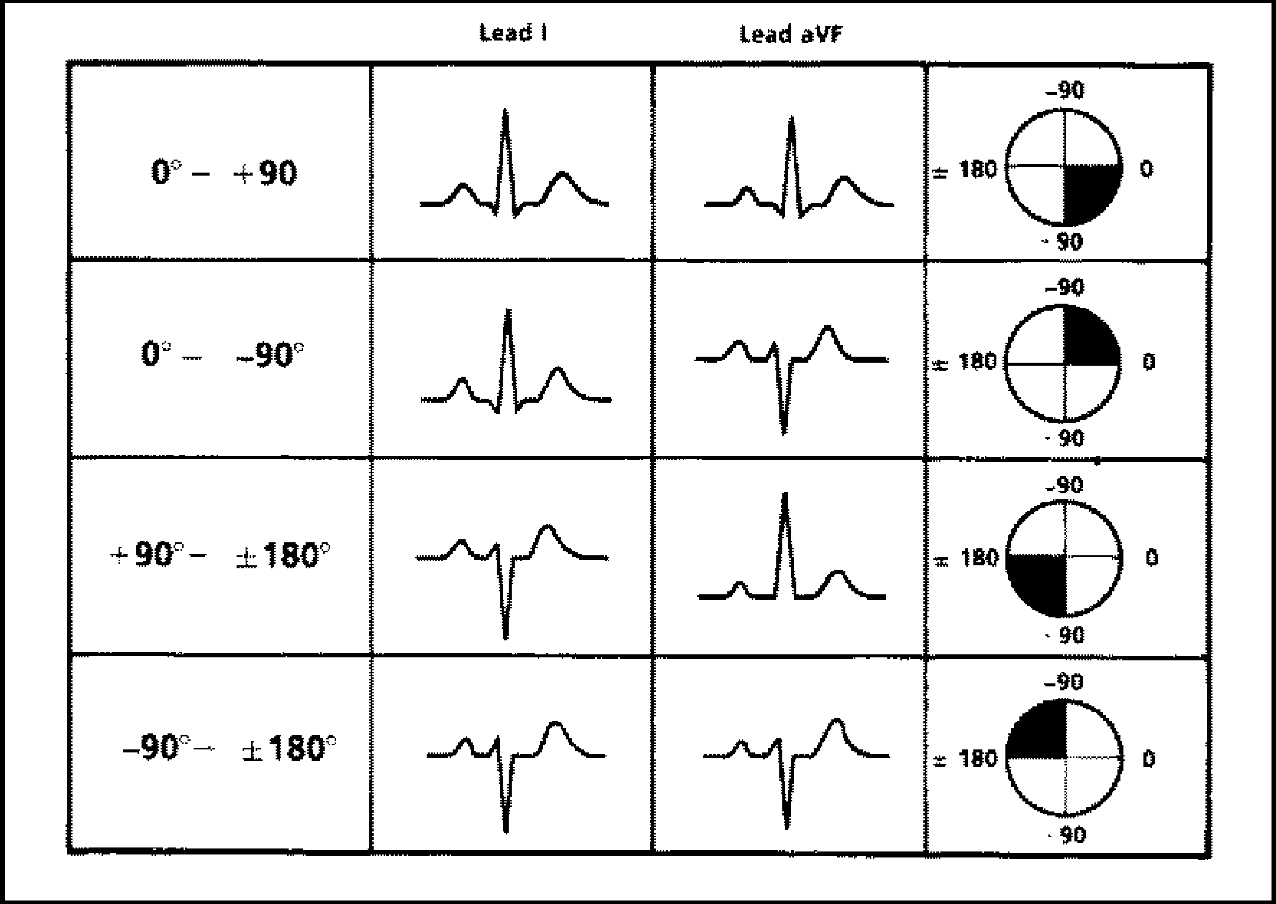


Lead I
Resultant Vector of Electrical Activity
Recording Axis of lead I (horizontal, right to left)
Recording Axis of lead aVF (vertical, downward)
R
P
Q
QRS complex
R
P
Q
S
Lead aVF



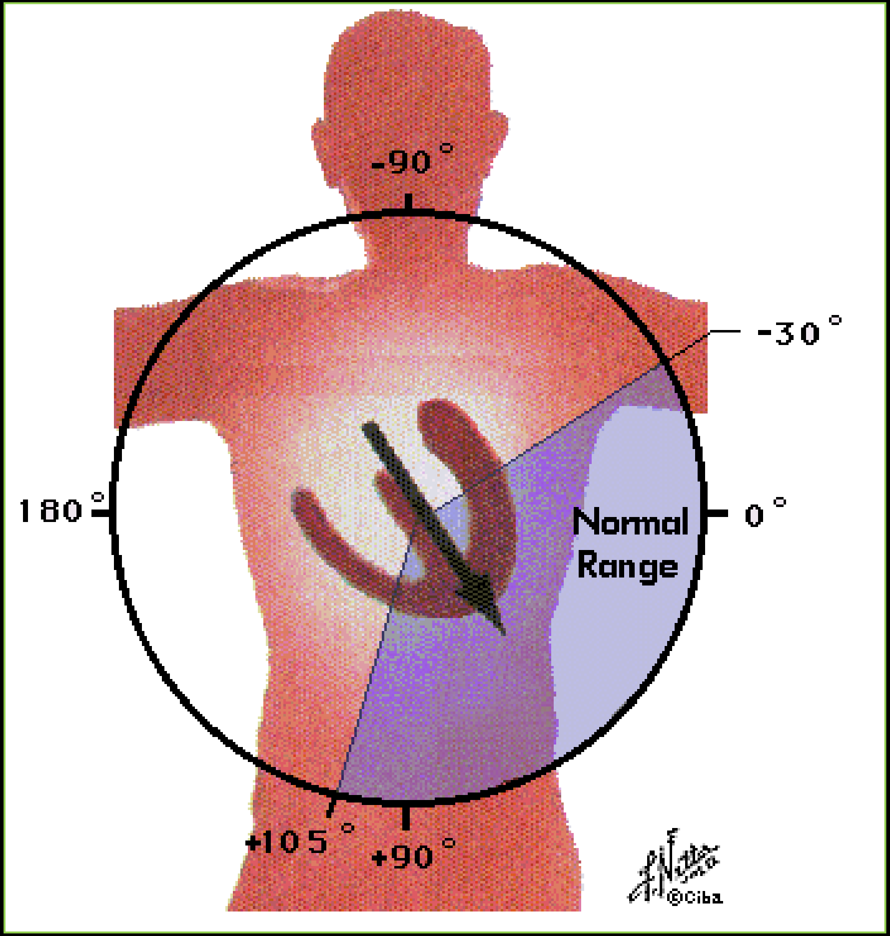
aVF
-90°
II
-120°
III
-60°
aVR
-150°
Right Superior
LAD
aVL
-30°
-180°
I
Leftward
I
0°
aVL
+150°
RAD
Normal
aVR
+30°
III
+120°
II
+60°
aVF
+90°

Quadrant determination



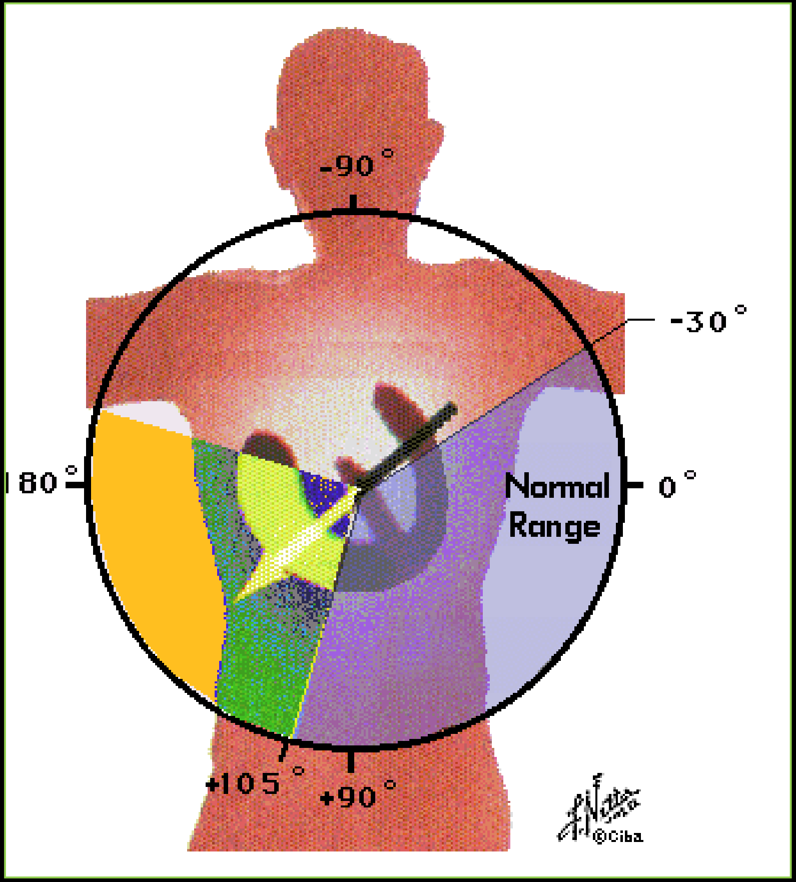
Normal electrical axis

The normal axis of the QRS is from +105 deg. to −30 deg. *



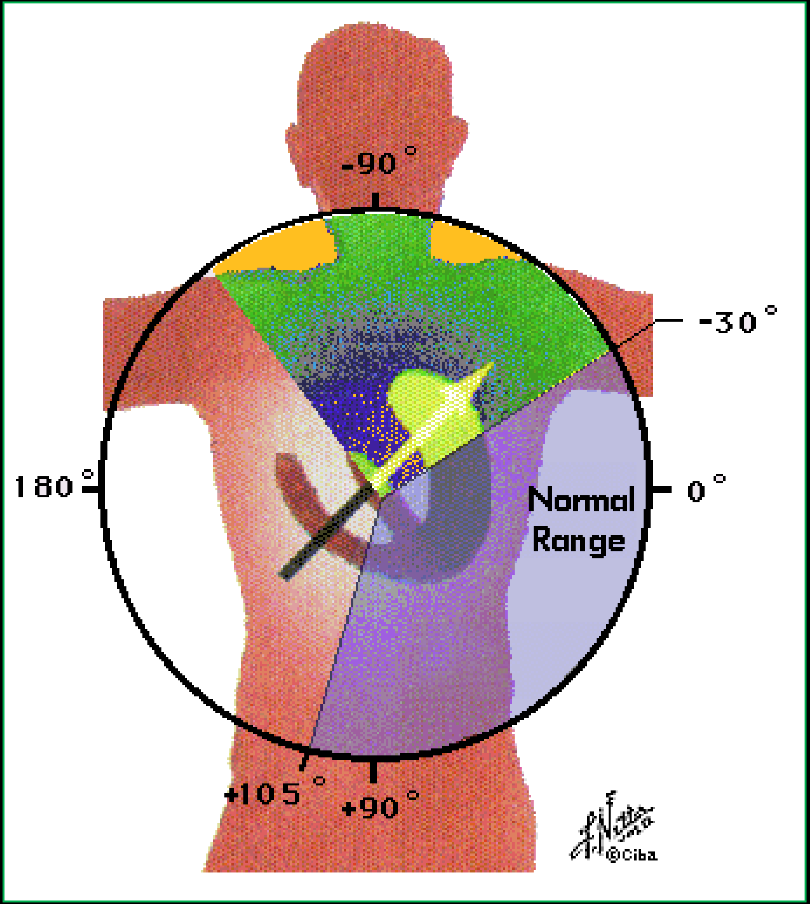
Right axis deviation

Right axis deviation is evident when the electrical axis is greater than +105 deg.



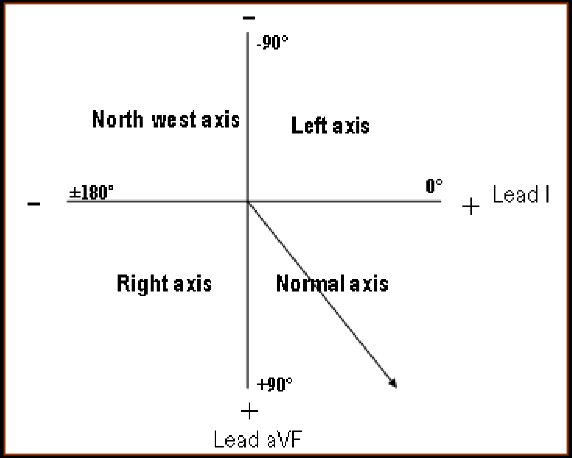
Left axis deviation

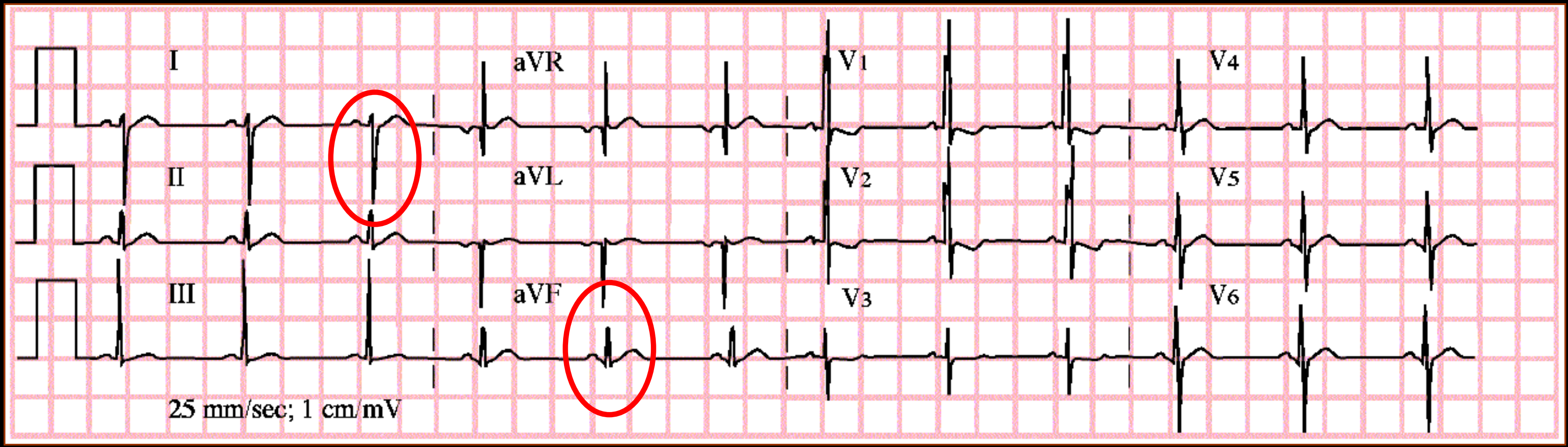
Left axis deviation is evident when the electrical axis is less than (i.e., to the left of) −30 deg.



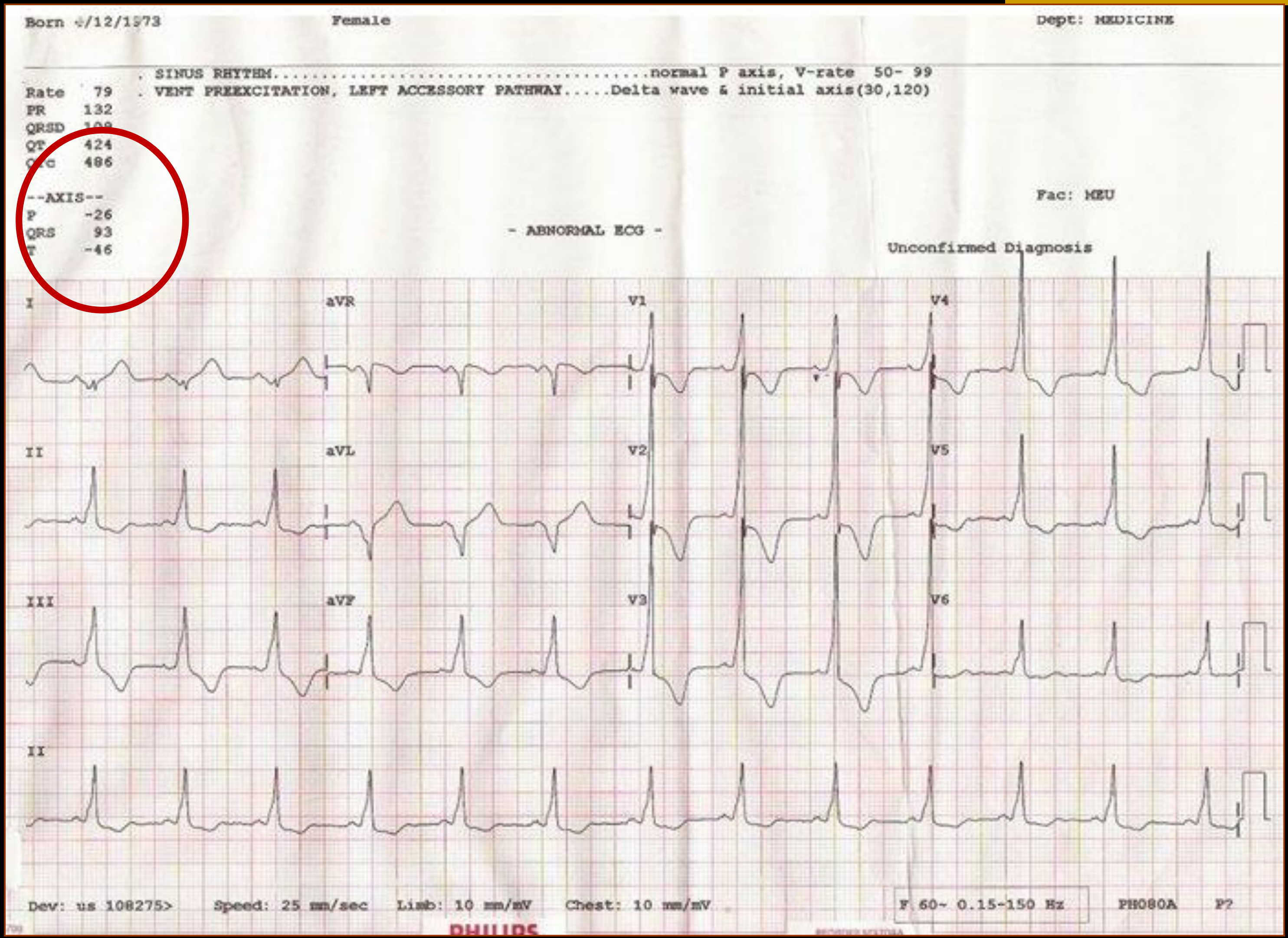
Electrical Axis

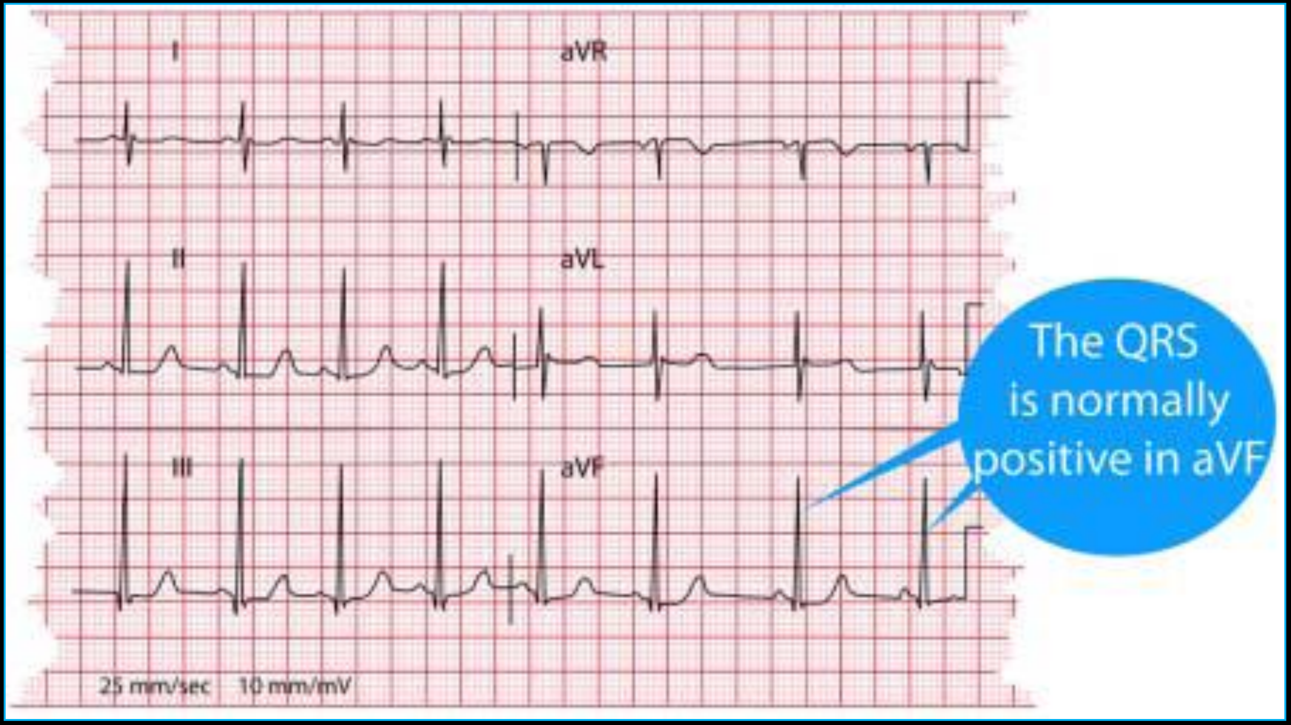
How to calculate?

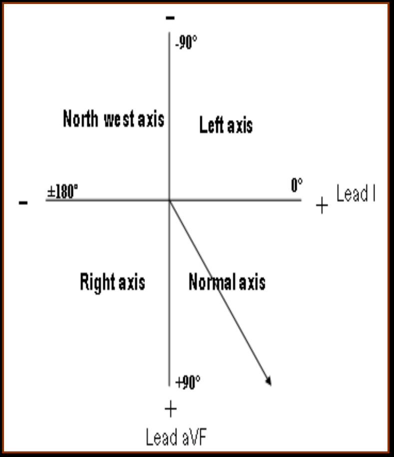


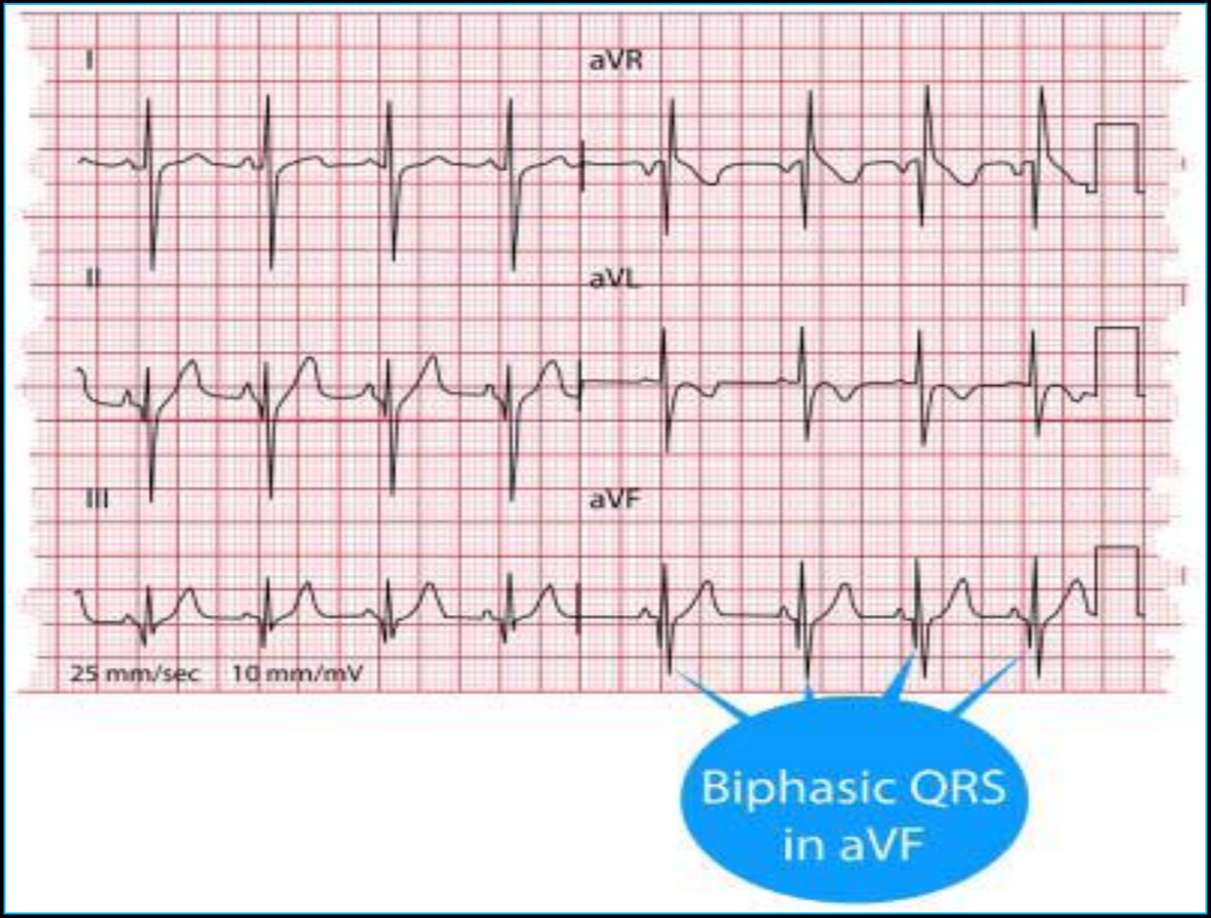


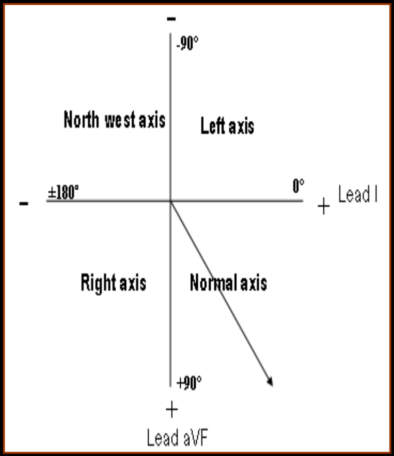
…or look at the top of the page

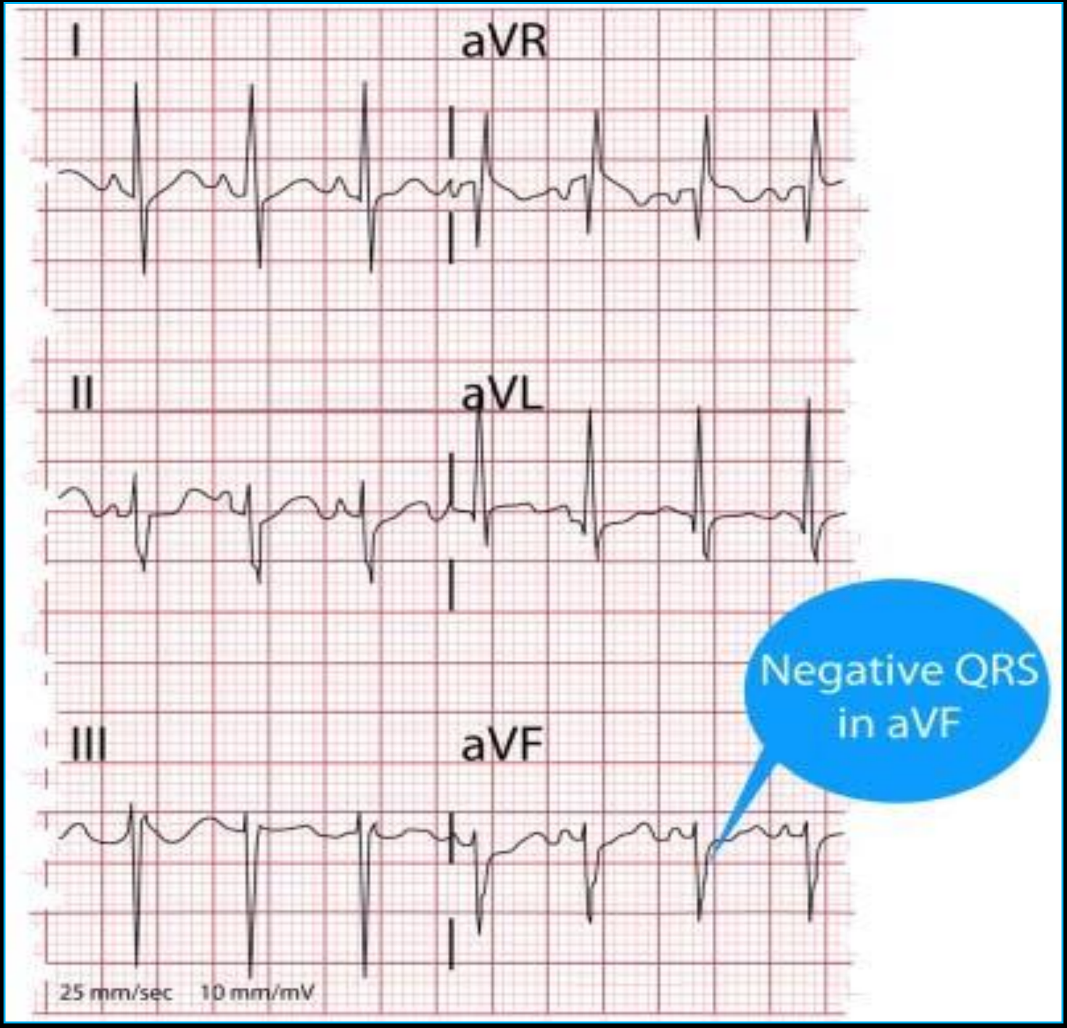


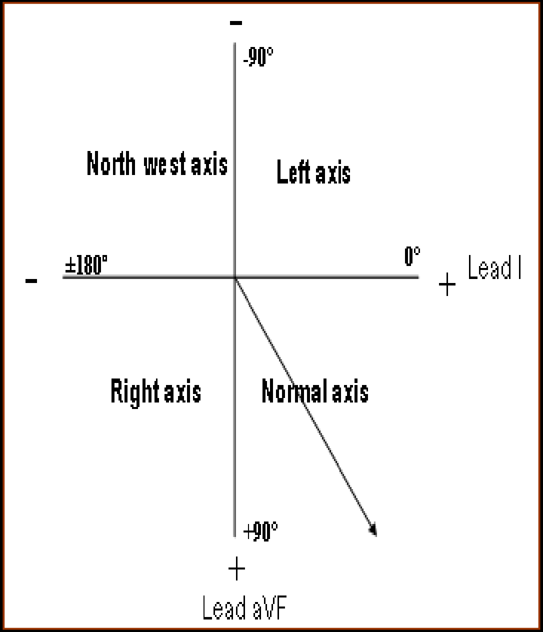

I
aVR
II
aVL
III
aVF
25 mm/sec
10 mm/mV
The QRS is normally positive in aVF


-90°
North west axis
Left axis
±180°
0°
Lead I
Right axis
Normal axis
+90°
Lead aVF


I
aVR
II
aVL
III
aVF
25 mm/sec
10 mm/mV
Biphasic QRS in aVF

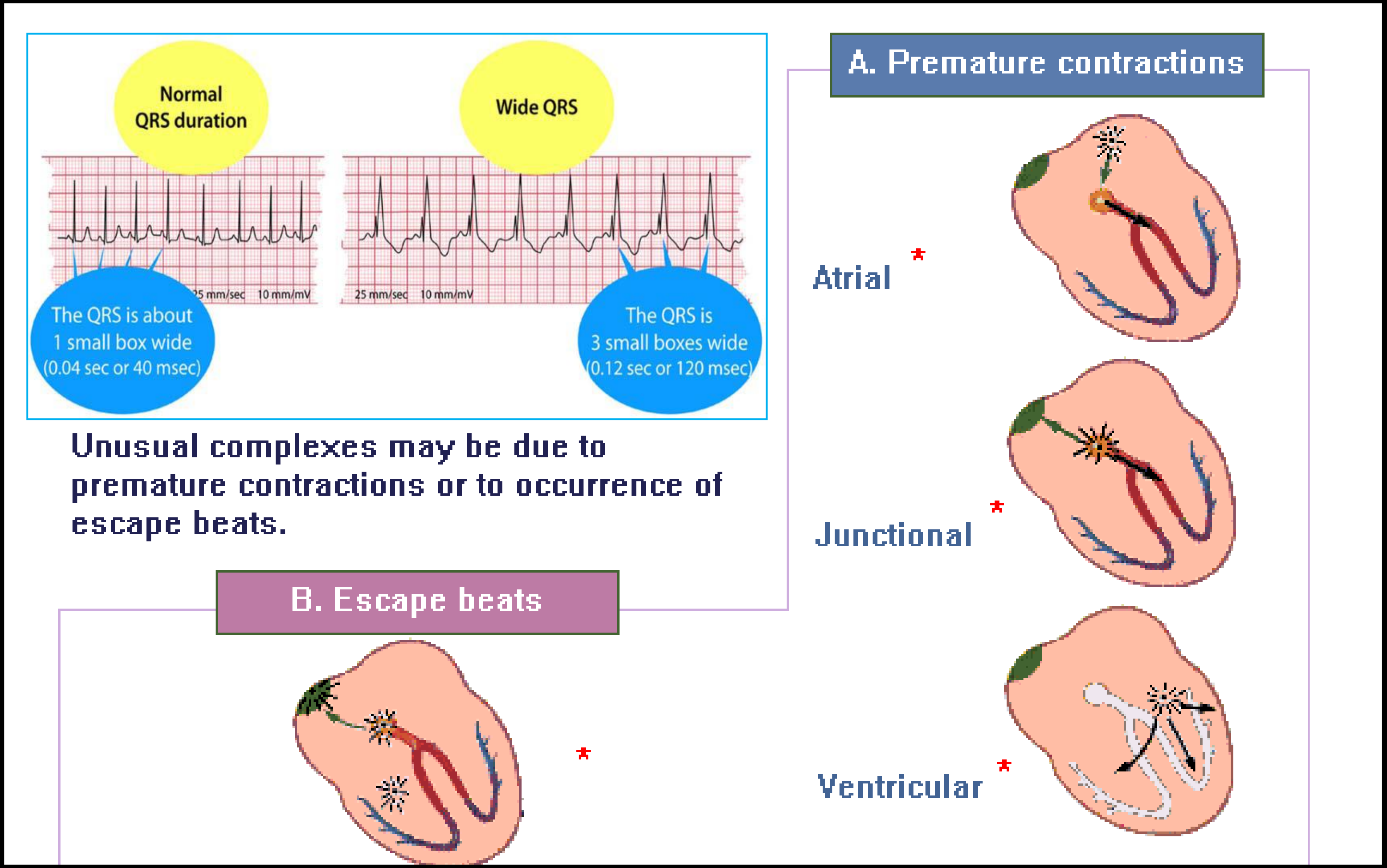

-90°
North west axis
Left axis
±180°
0°
Lead I
Right axis
Normal axis
+90°
Lead aVF

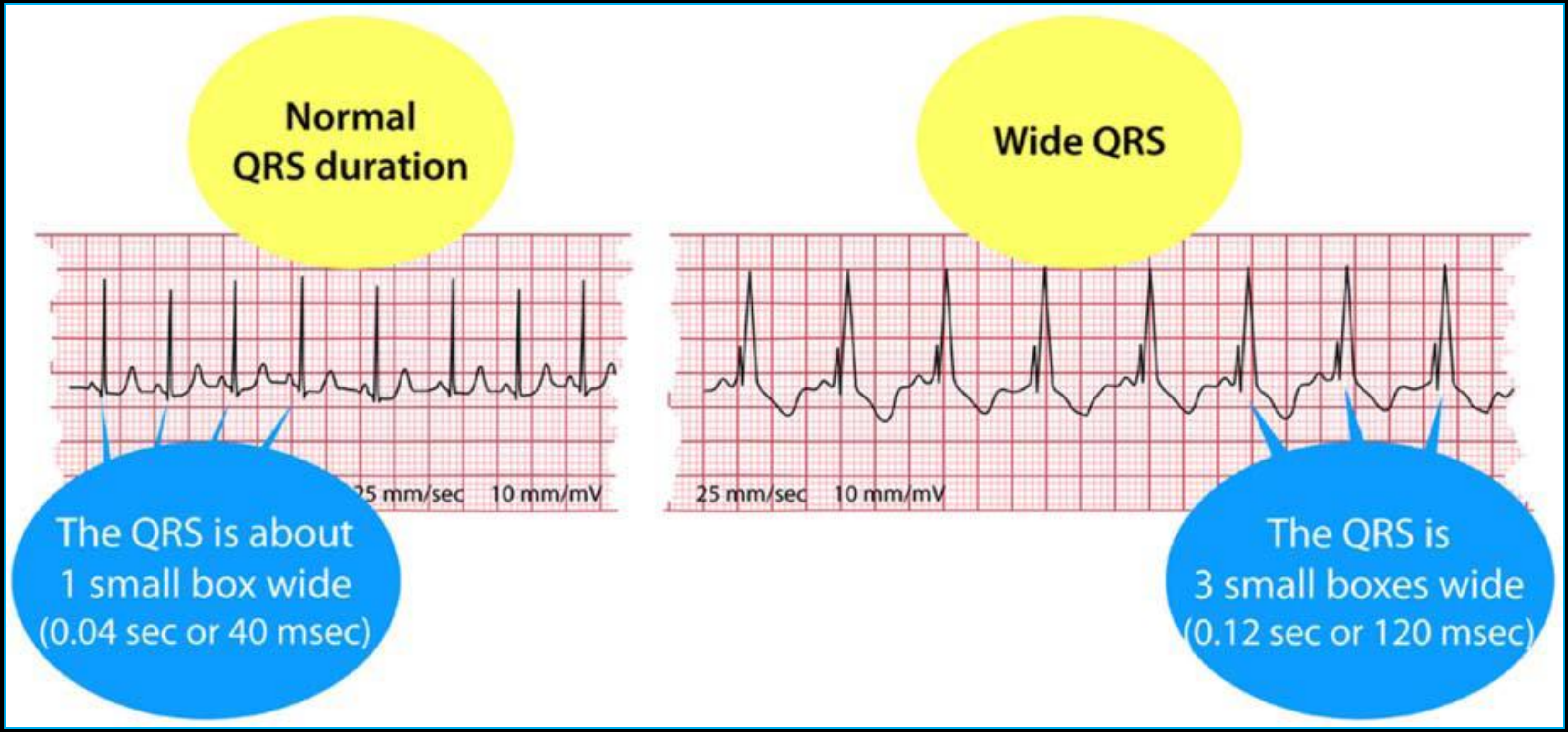

I
aVR
II
aVL
III
aVF
25 mm/sec
10 mm/mV
Negative QRS in aVF


-90°
North west axis
Left axis
±180°
0°
Lead I
Right axis
Normal axis
+90°
Lead aVF

PART : III

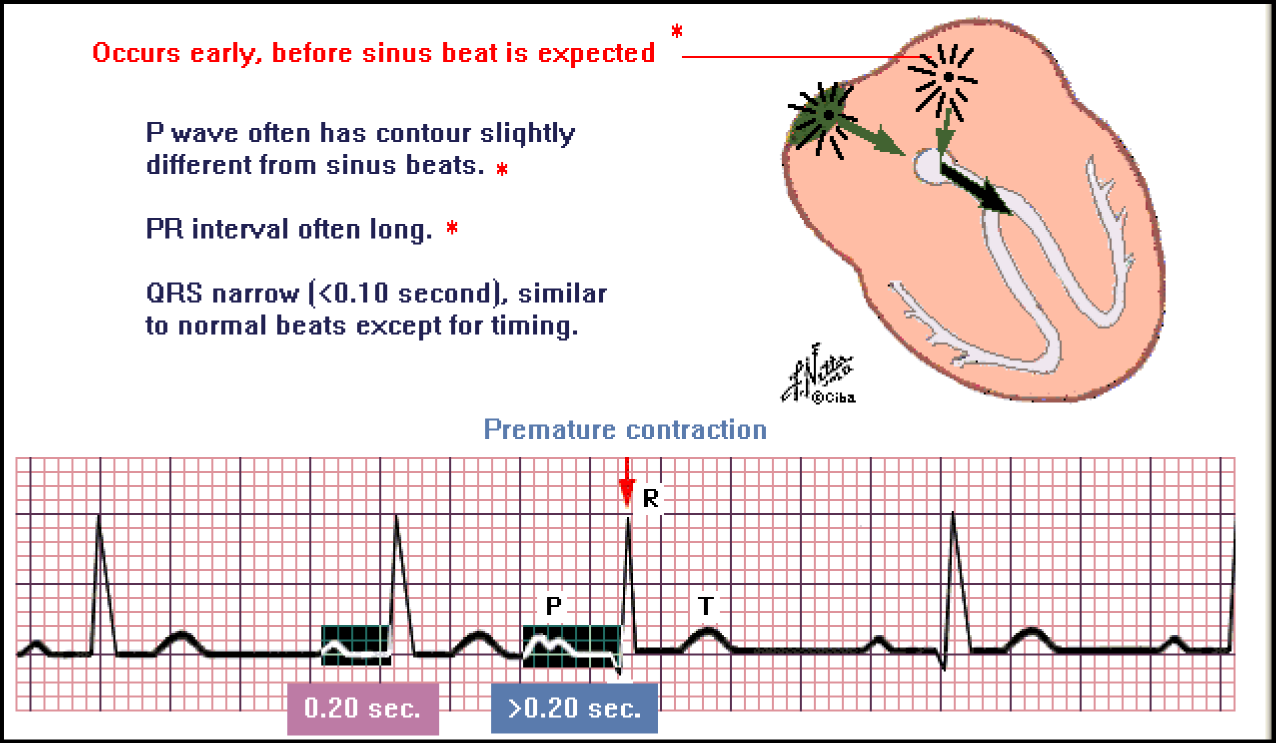
Unusual Complexes :timing or contour



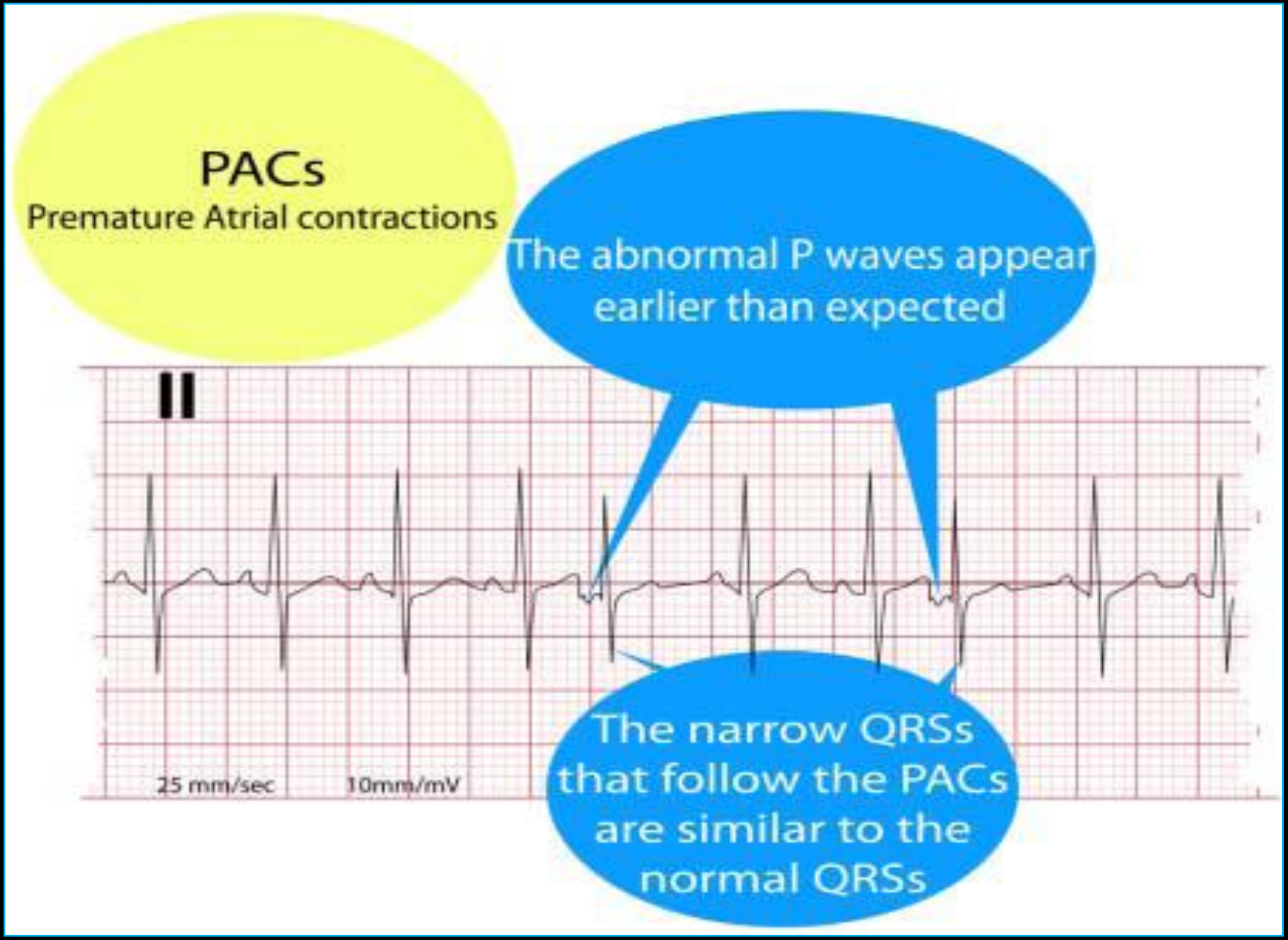


Normal
QRS duration
Wide QRS
25 mm/sec 10 mm/mV
25 mm/sec 10 mm/mV
The QRS is about
1 small box wide
(0.04 sec or 40 msec)
The QRS is
3 small boxes wide
(0.12 sec or 120 msec)

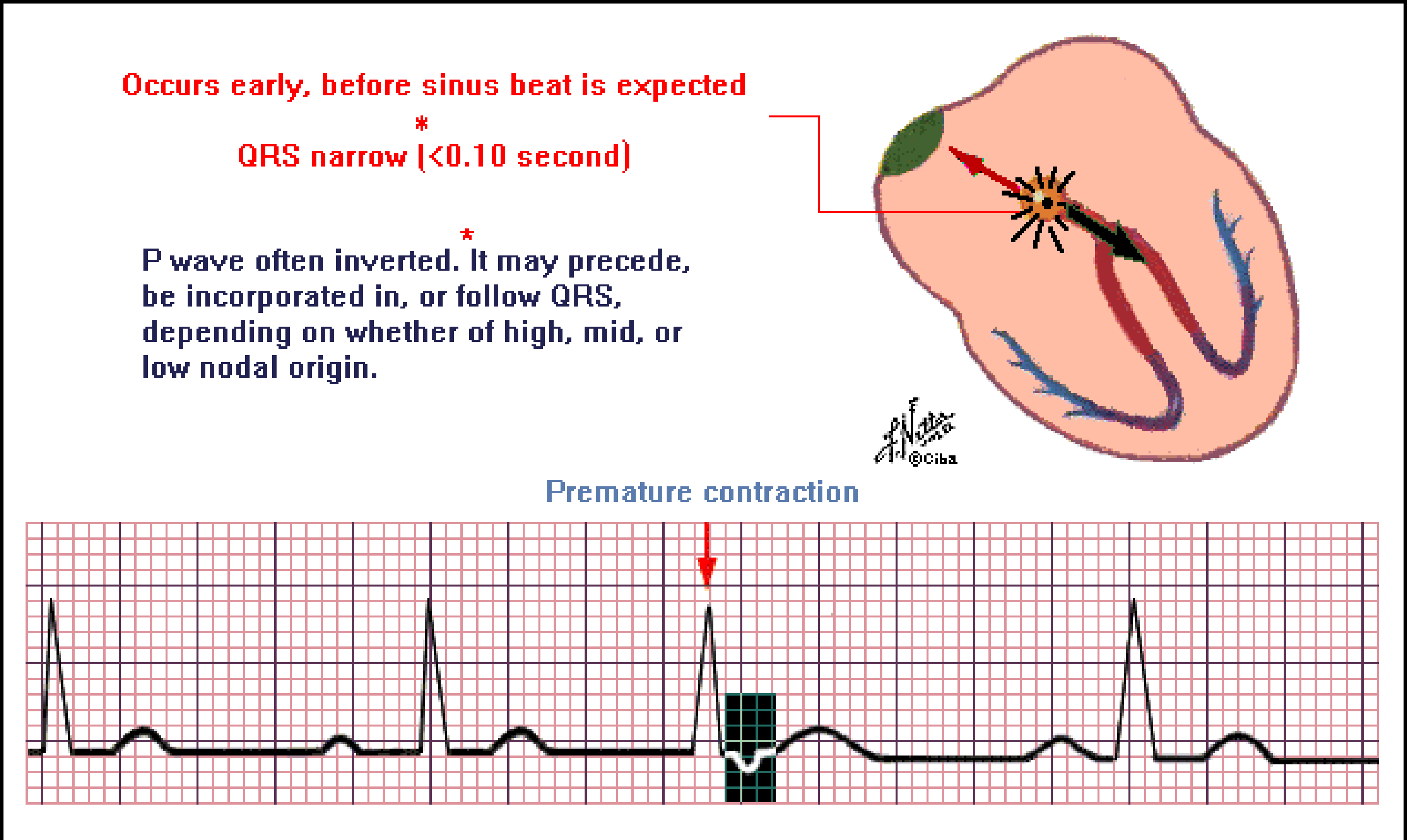
Unusual Complex : PAC



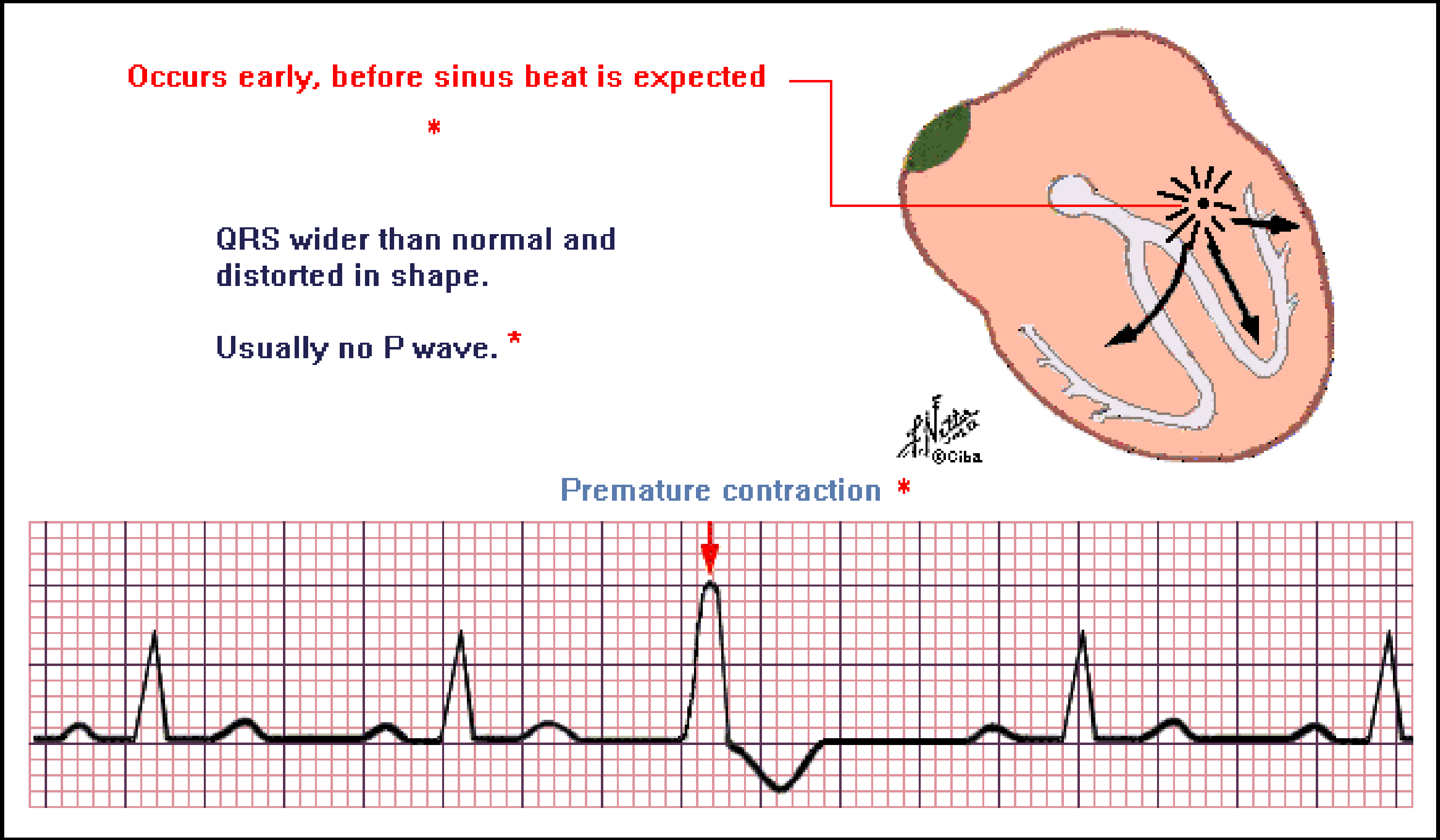
Unusual Complex : PAC



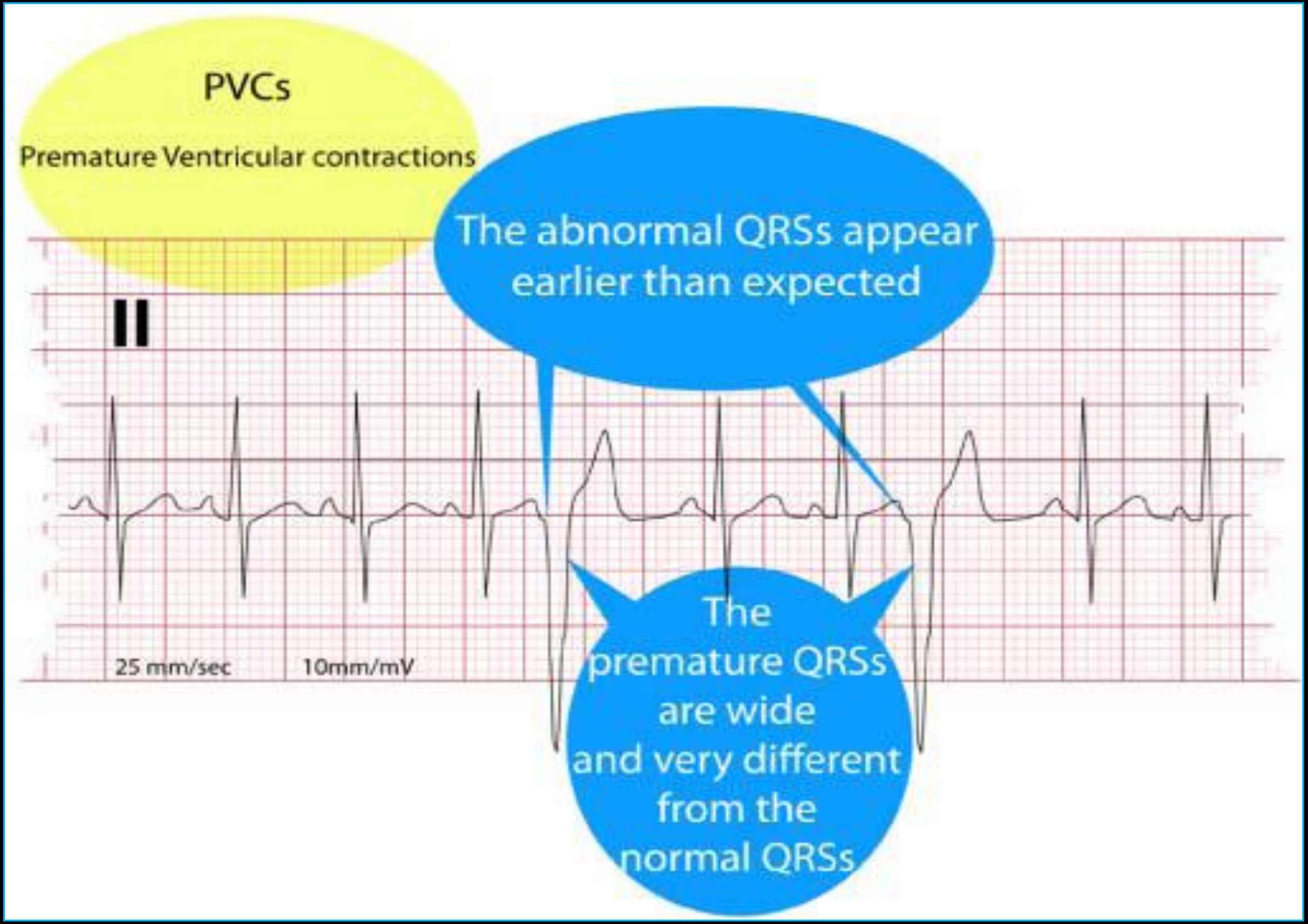
Unusual Complex : PJC



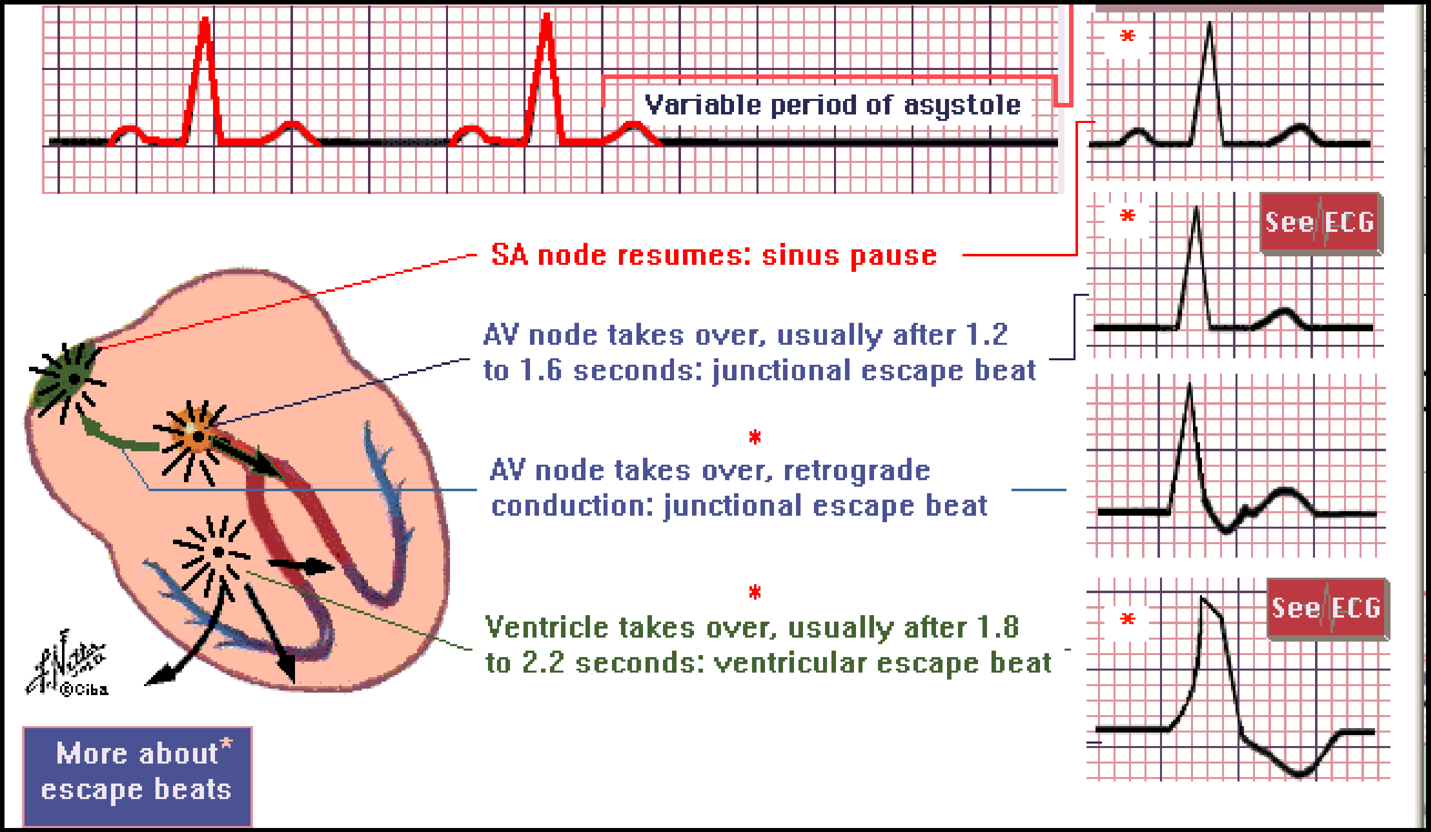
Unusual Complex : PVC



Unusual Complex : PVC



Unusual Complex : Escape beats

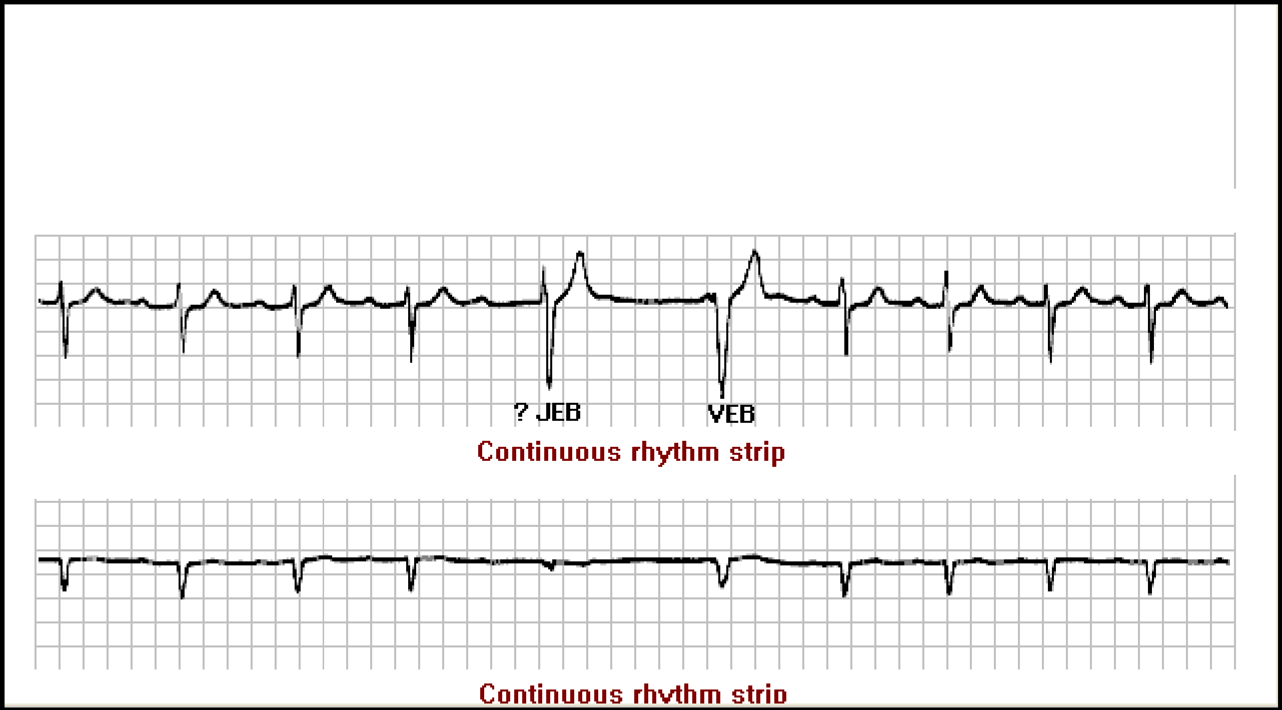


Self test

Continuous rhythm strip

Continuous rhythm strip

Self test

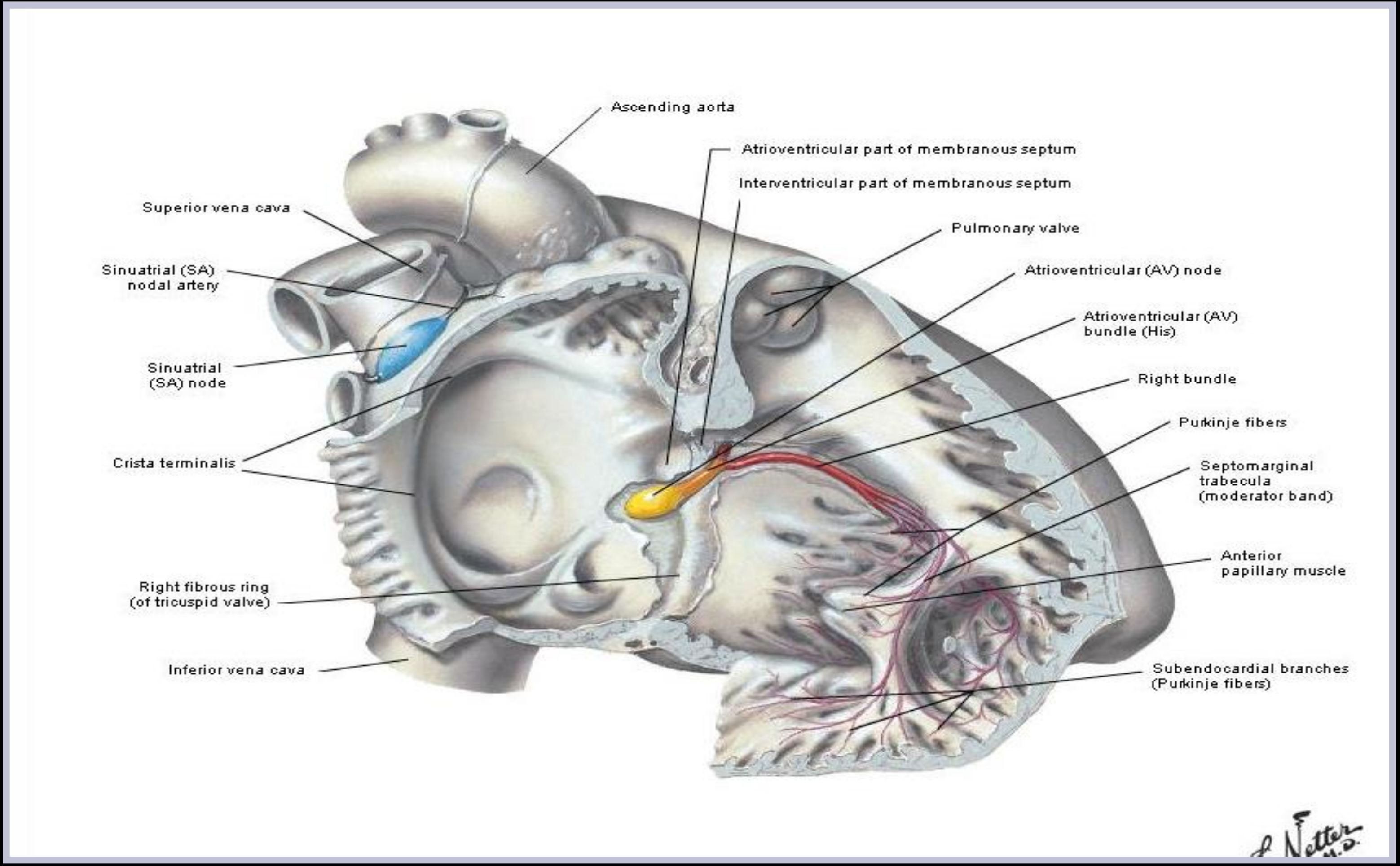


IV-Conduction & Block

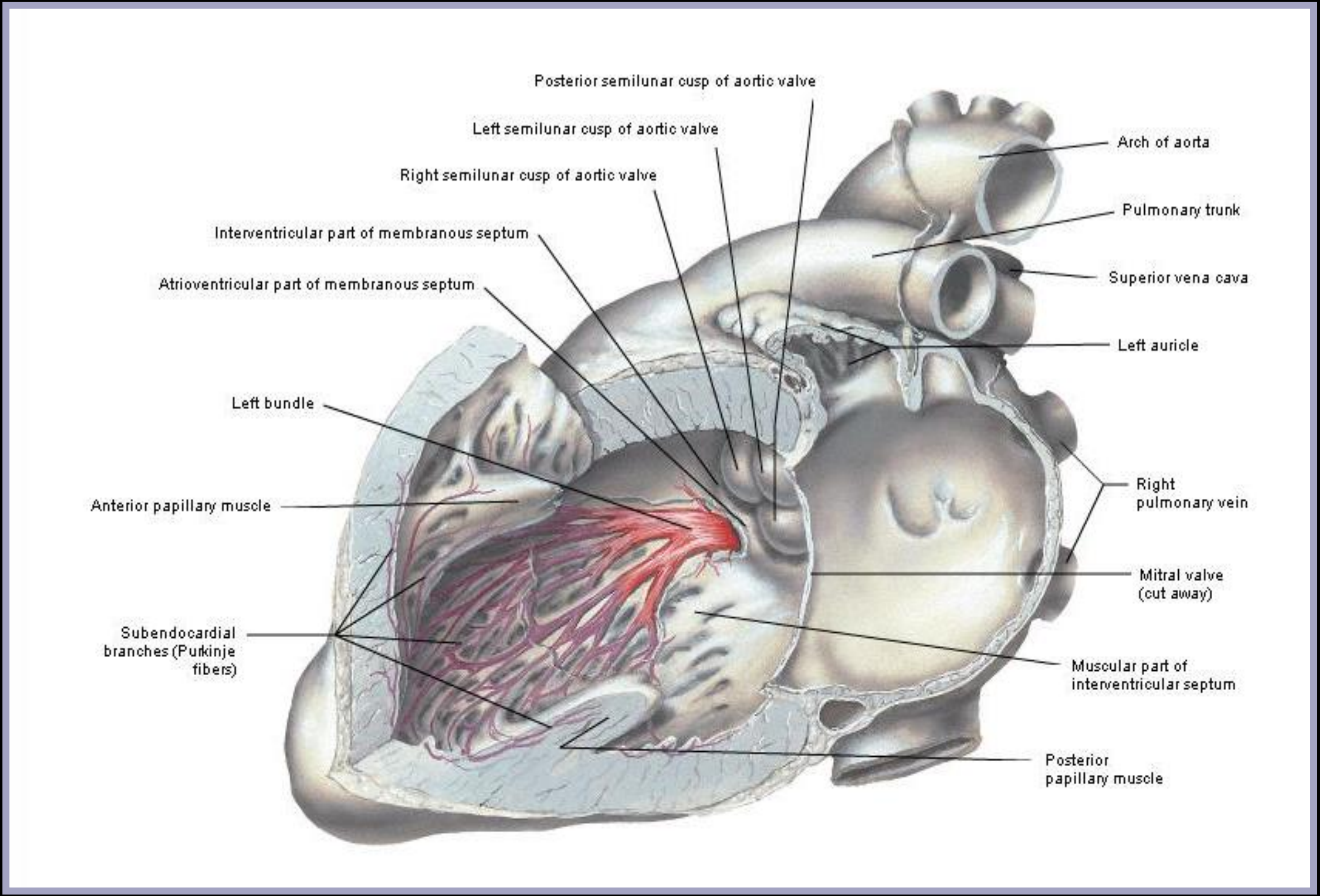
-Atrio-Ventricular Conduction

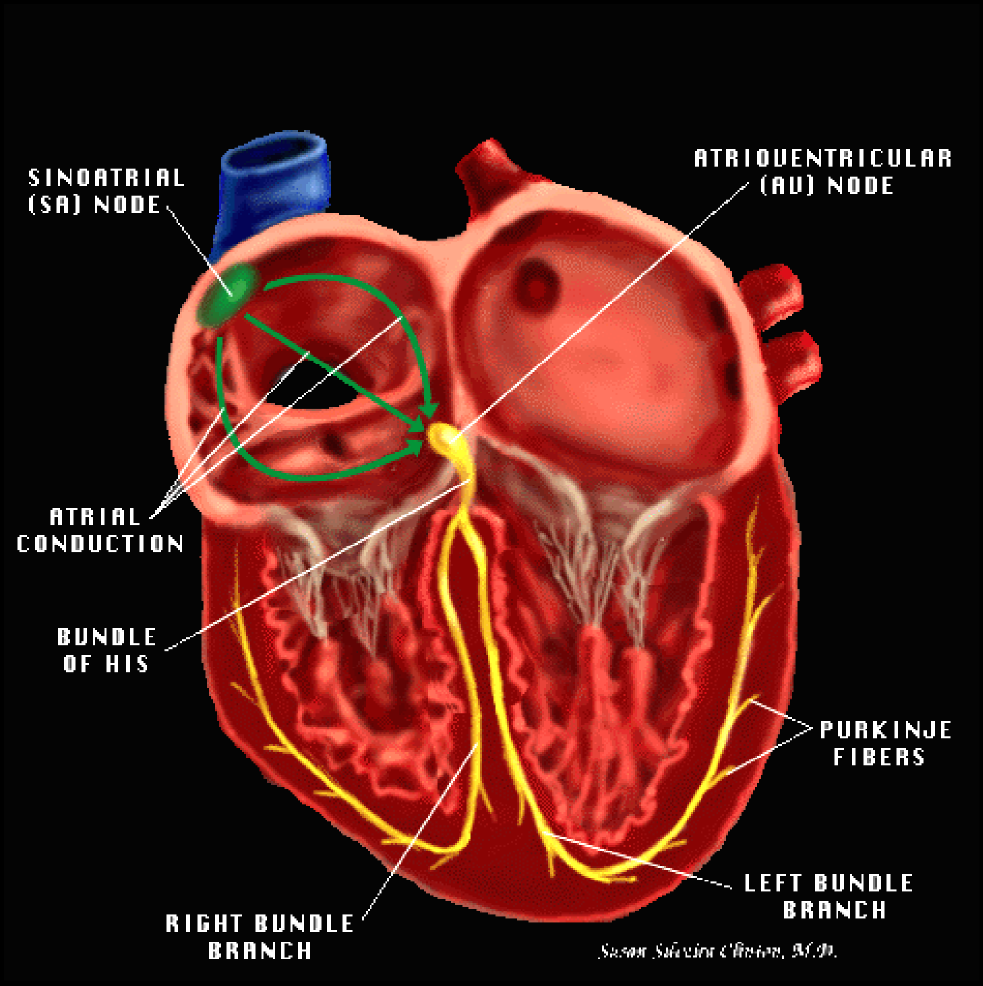
-Intra-Ventricular Conduction Defects

Conducting system :Right side



Conducting System :left side



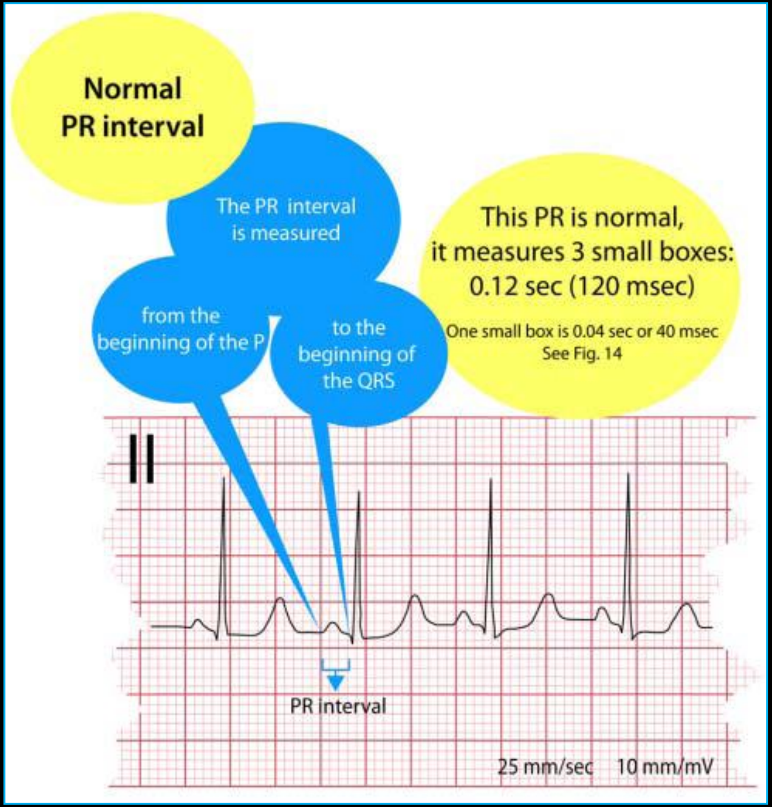

SINOATRIAL (SA) NODE
ATRIOVENTRICULAR (AV) NODE
ATRIAL CONDUCTION
BUNDLE OF HIS
PURKINJE FIBERS
LEFT BUNDLE BRANCH
RIGHT BUNDLE BRANCH
Susan Salvia Clinton, M.D.

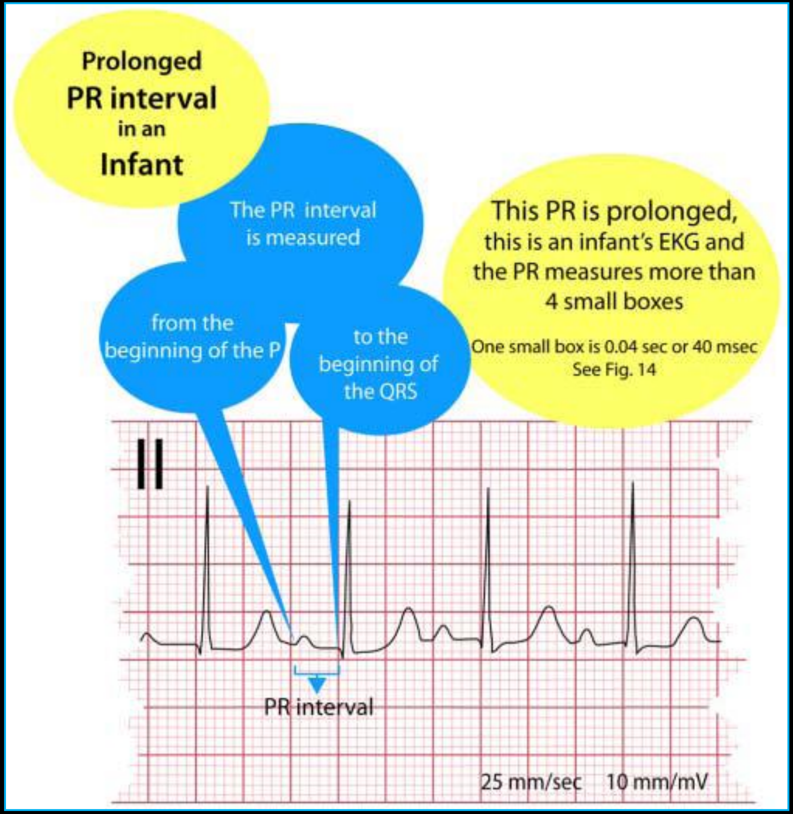
Assessment of Atrio-ventricular conduction :

AV conduction is assessed by examining the relationship between P waves and QRS complexes.

The basic question is whether P waves are :

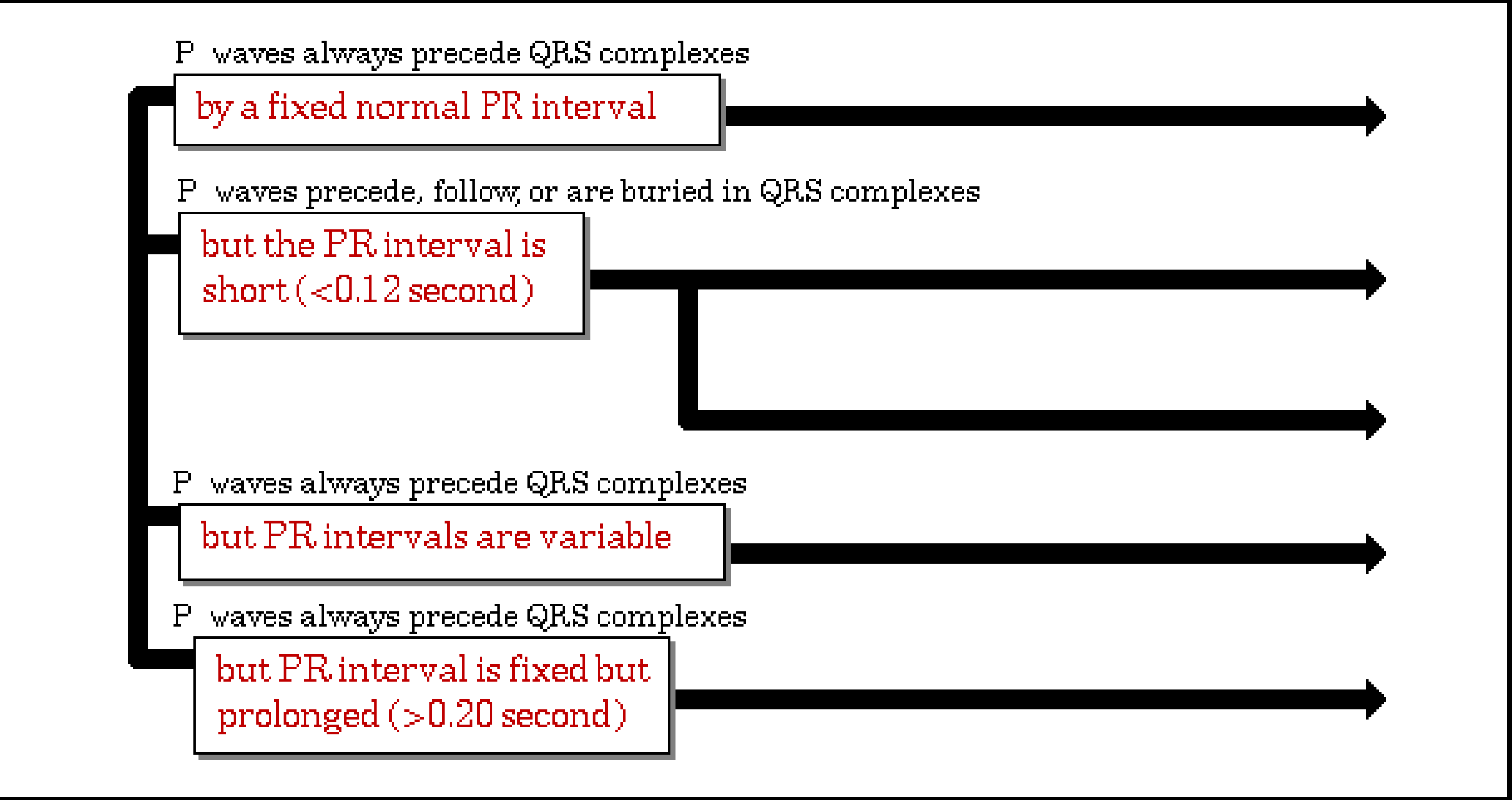
P wave always related to QRS
P wave sometimes related to QRS
P wave never related to QRS


Normal
PR interval
The PR interval
is measured
from the
beginning of the P
to the
beginning of
the QRS
This PR is normal,
it measures 3 small boxes:
0.12 sec (120 msec)
One small box is 0.04 sec or 40 msec
See Fig. 14
II
PR interval
25 mm/sec 10 mm/mV


Prolonged
PR interval
in an
Infant
The PR interval
is measured
from the
beginning of the P
to the
beginning of
the QRS
This PR is prolonged,
this is an infant's EKG and
the PR measures more than
4 small boxes
One small box is 0.04 sec or 40 msec
See Fig. 14
II
PR interval
25 mm/sec 10 mm/mV

Atrio-ventricular conduction :

P wave always related to QRS

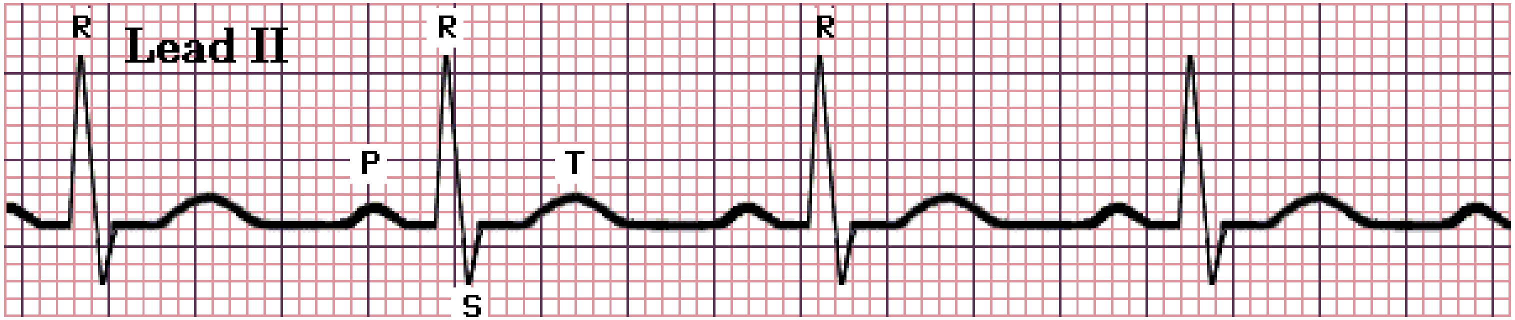


P wave always related to QRS

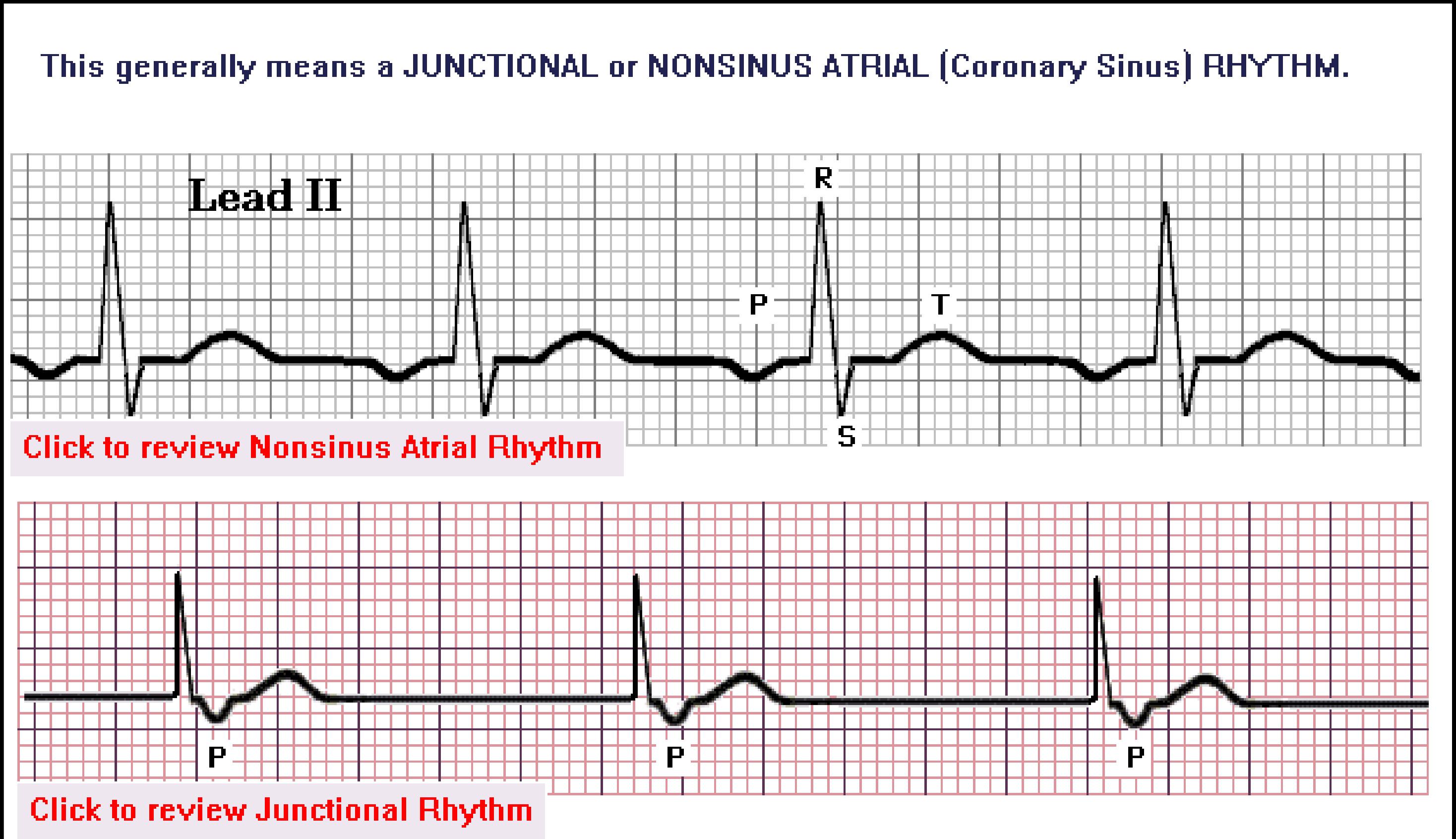
When a P wave is preceded by a

FIXED NORMAL PR INTERVAL,

then AV conduction is normal, and the diagnosis is Normal Sinus Rhythm.



P wave always related to QRS



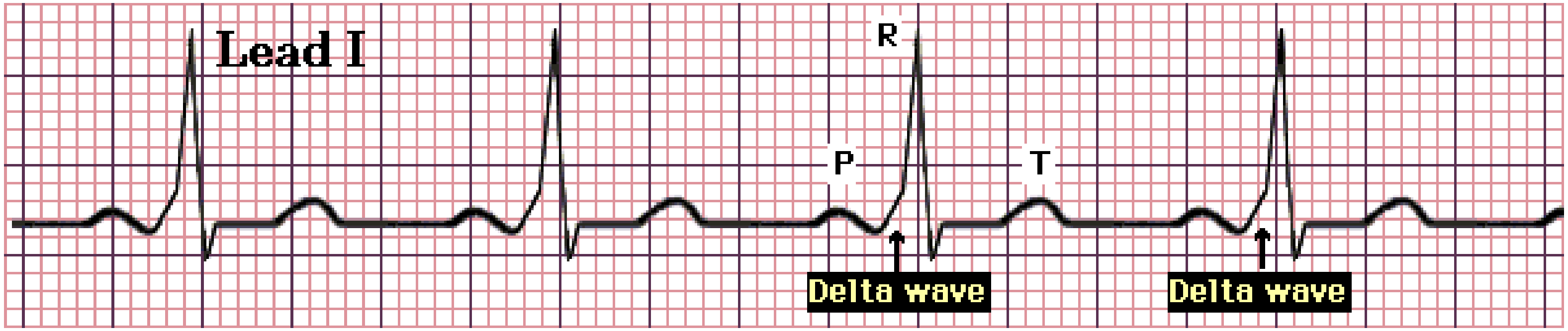
P wave always related to QRS

Wolff-Parkinson-White Syndrome (Preexcitation Syndrome) (click to review)

Atrial activation is transmitted with unusual rapidity to the ventricle.

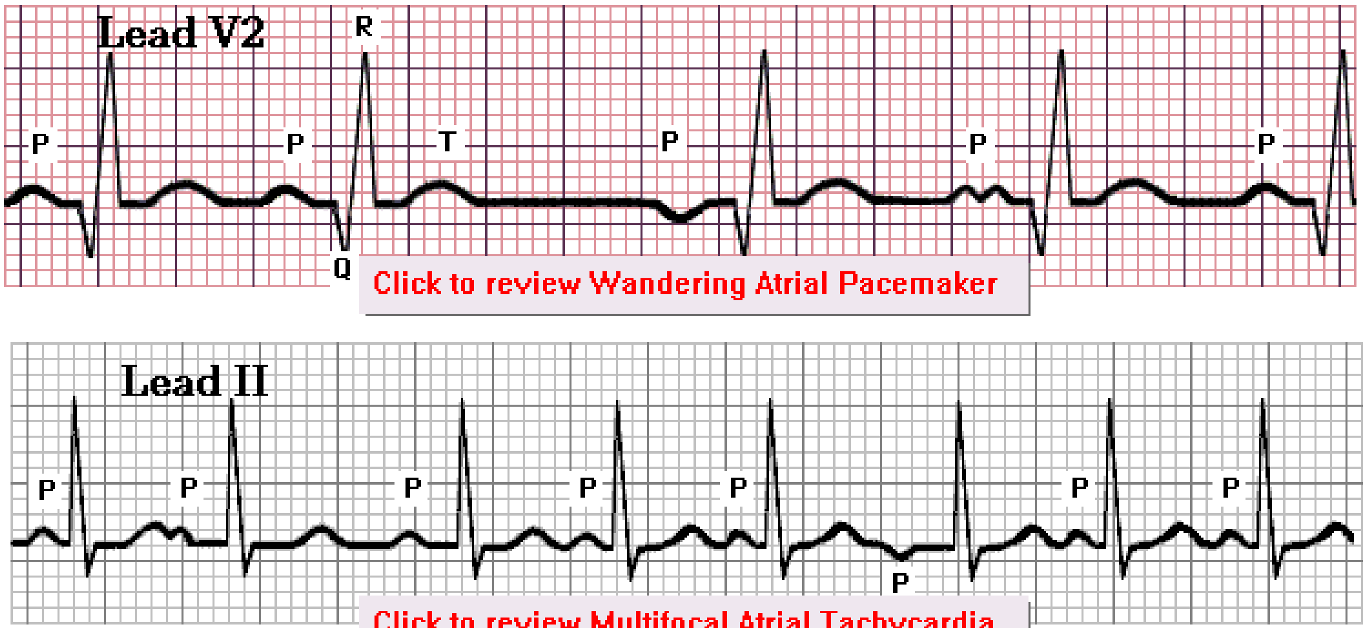
This unusual rapidity is due to the bypass tract in the WPW syndrome. The bypass tract allows the impulse to leak to the ventricular muscle without the delay at the AV node.

After normal delay at AV node, impulses also arrive at ventricles via normal route to continue depolarization.

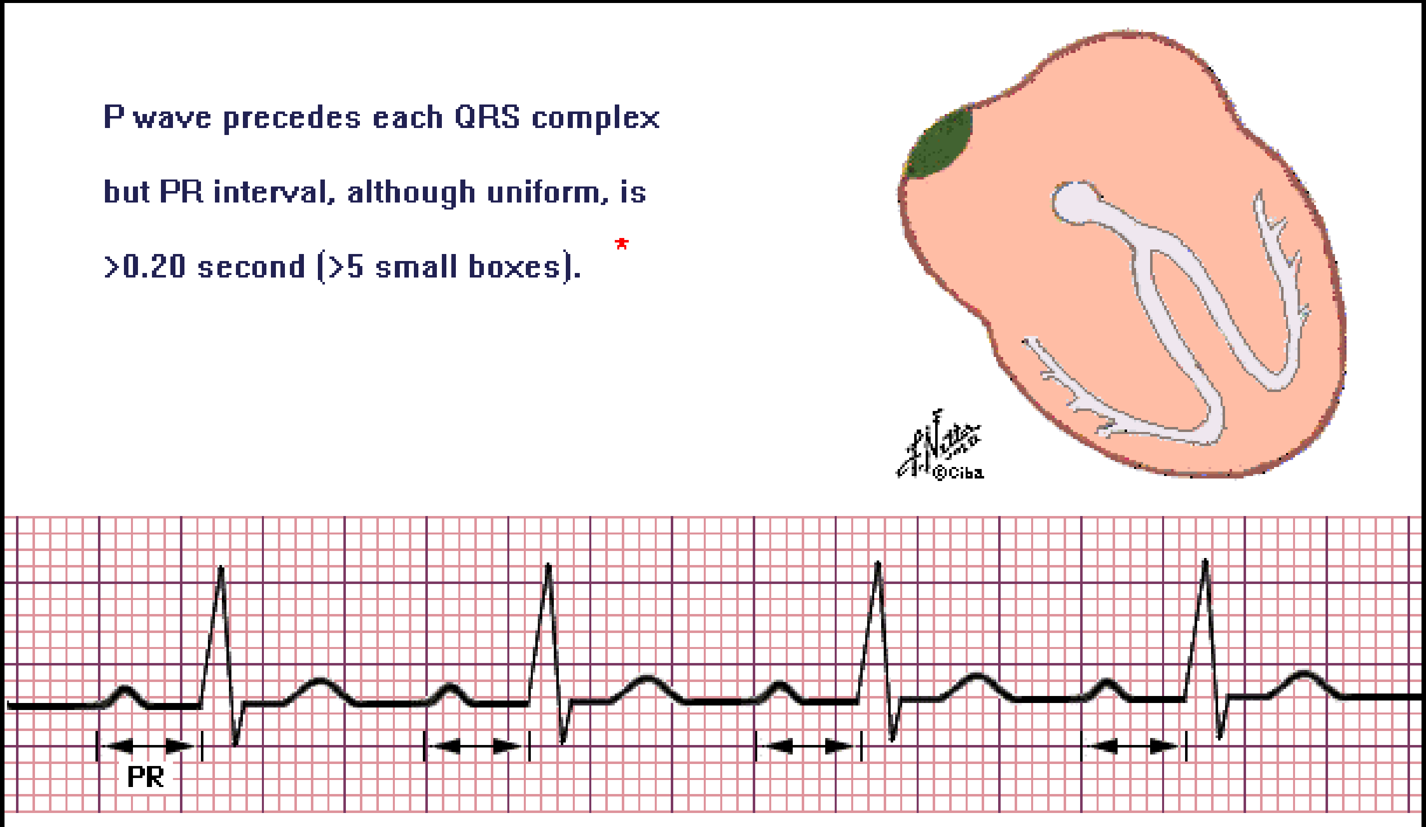


P wave always related to QRS

PR Variable: If P waves always precede QRS complexes but PR intervals are variable, then supraventricular activation is presumed to originate from varying sites, characteristic of wandering atrial pacemaker or multifocal atrial tachycardia.



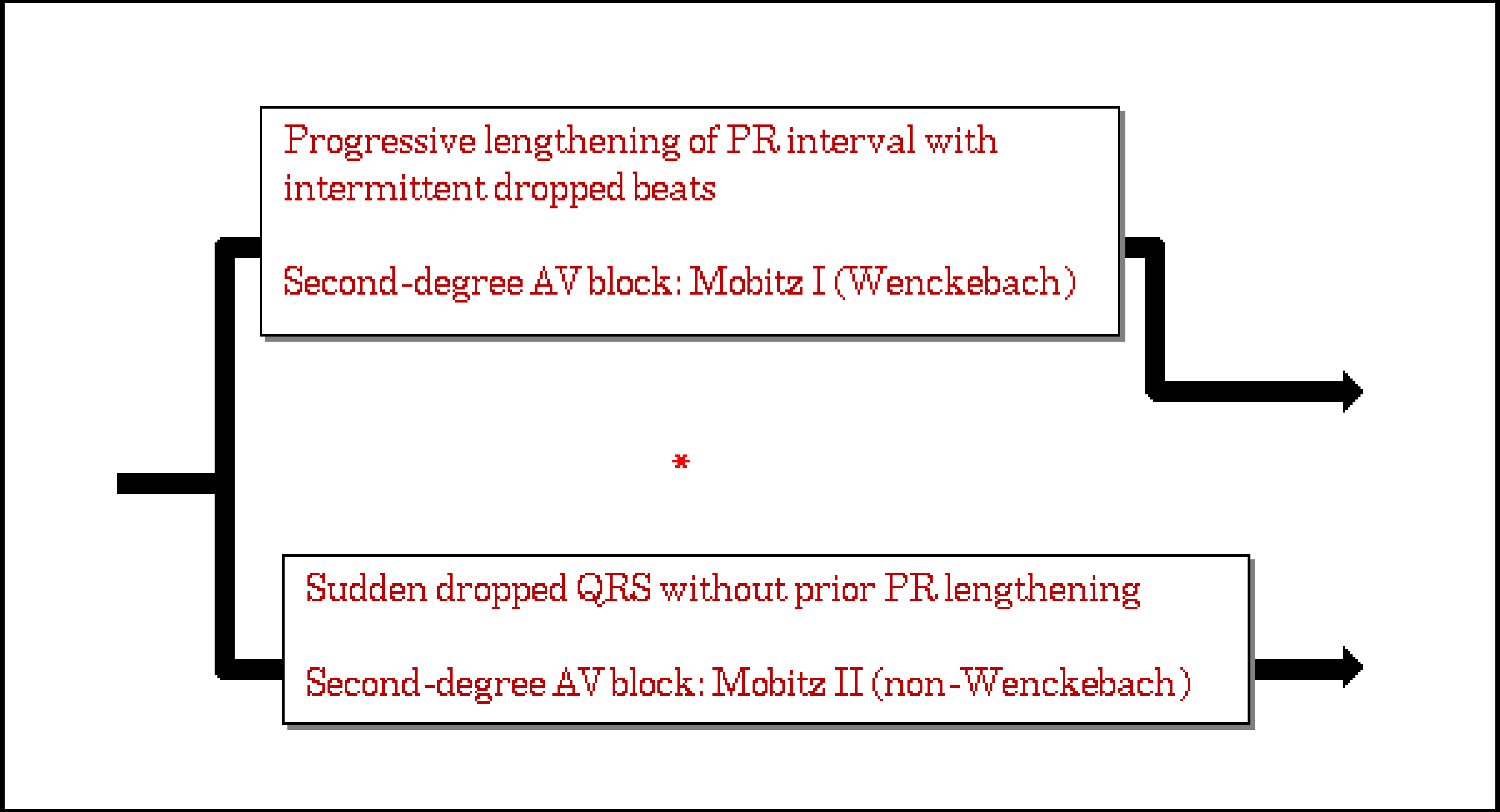
P wave always related to QRS



Fixed but prolonged PR interval; first-degree AV block

Atrio-ventricular conduction :

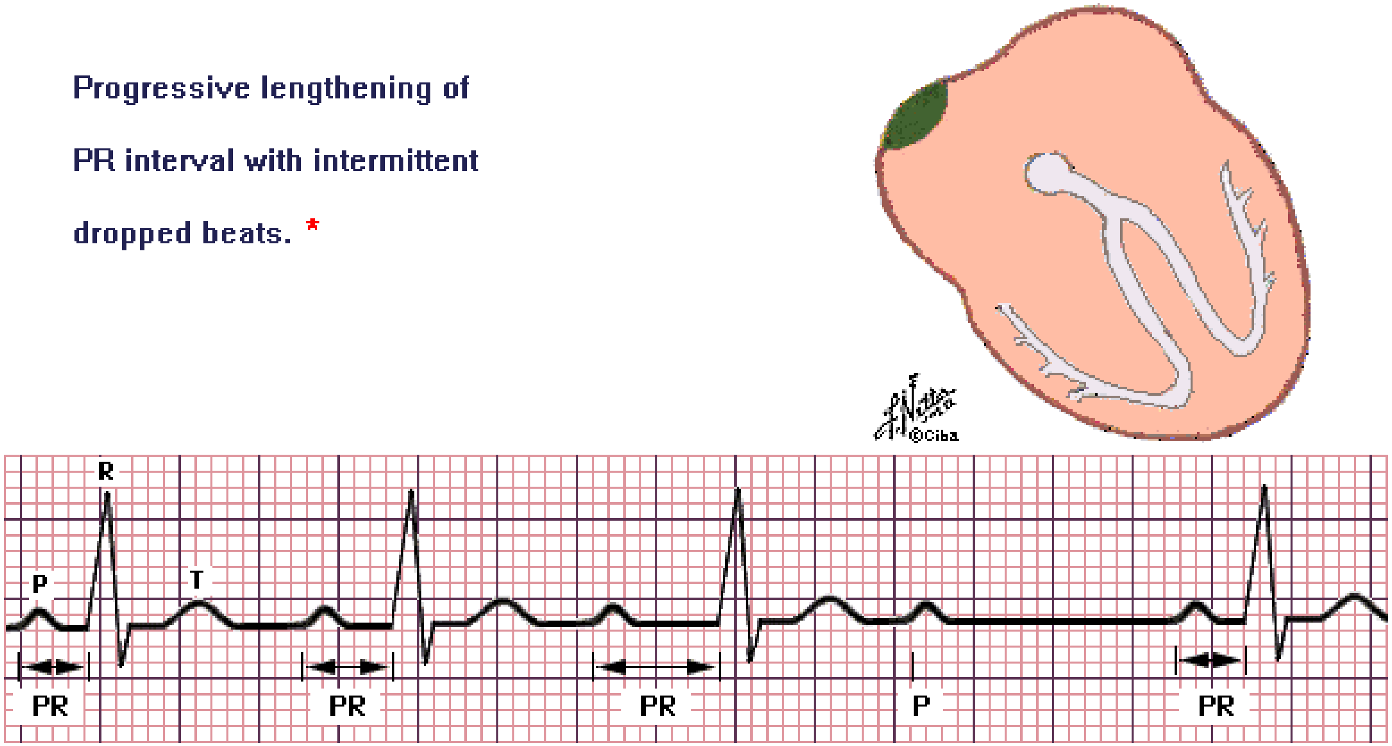
P wave sometimes related to QRS

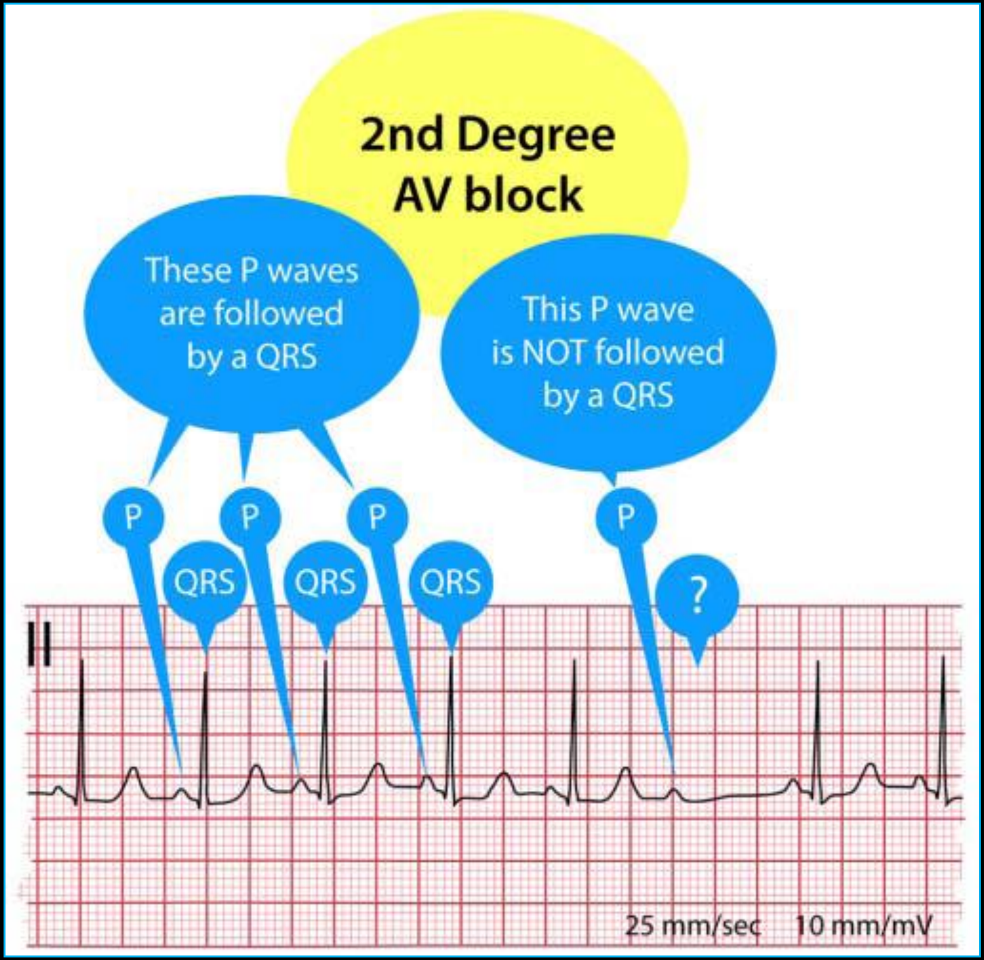


P wave sometimes related to QRS

A. Second-Degree AV Block: Mobitz I

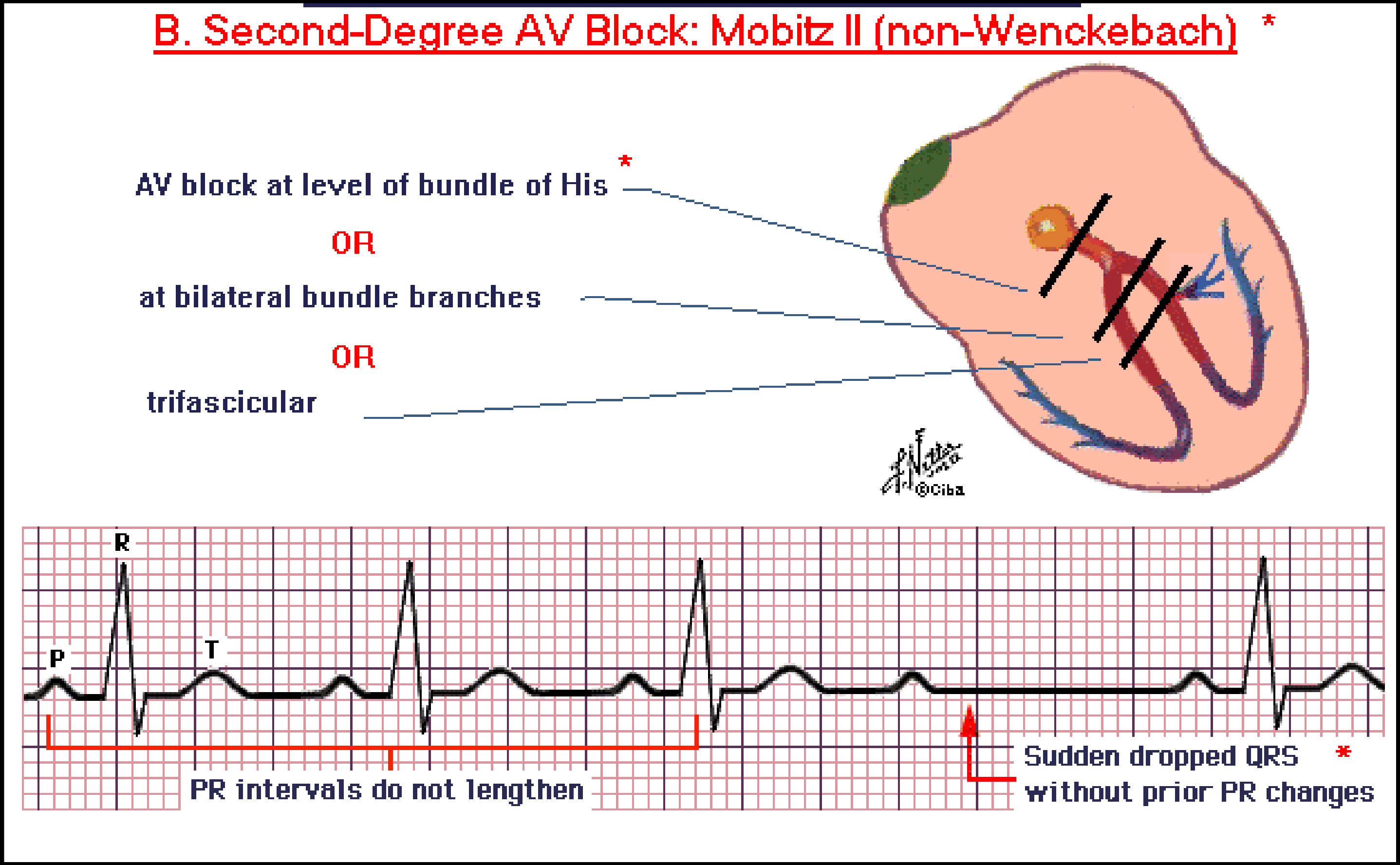
Progressive lengthening of PR interval with intermittent dropped beats. *





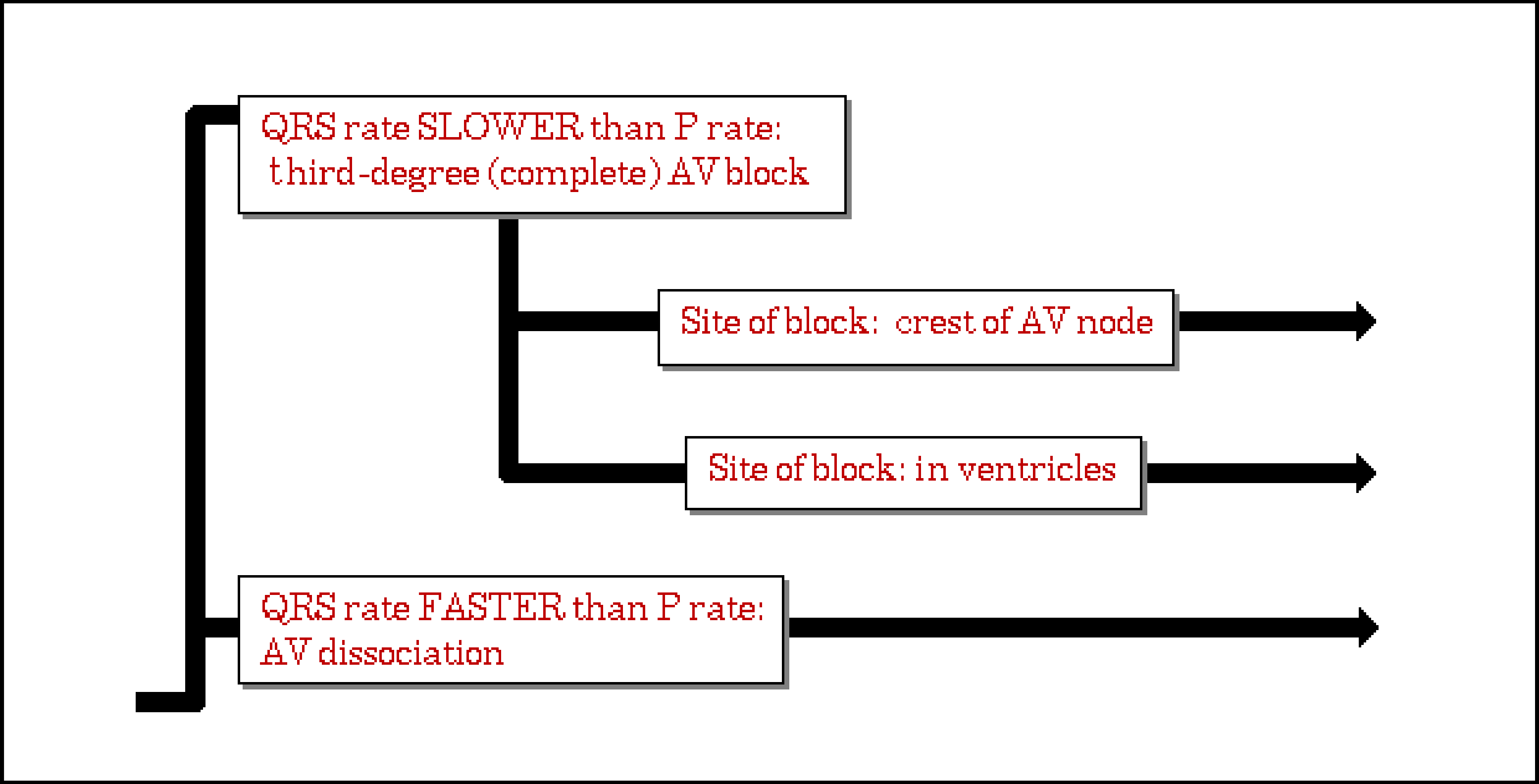
2nd Degree AV block
These P waves are followed by a QRS
This P wave is NOT followed by a QRS
P
P
P
P
QRS
QRS
QRS
?
II
25 mm/sec
10 mm/mV

P wave sometimes related to QRS

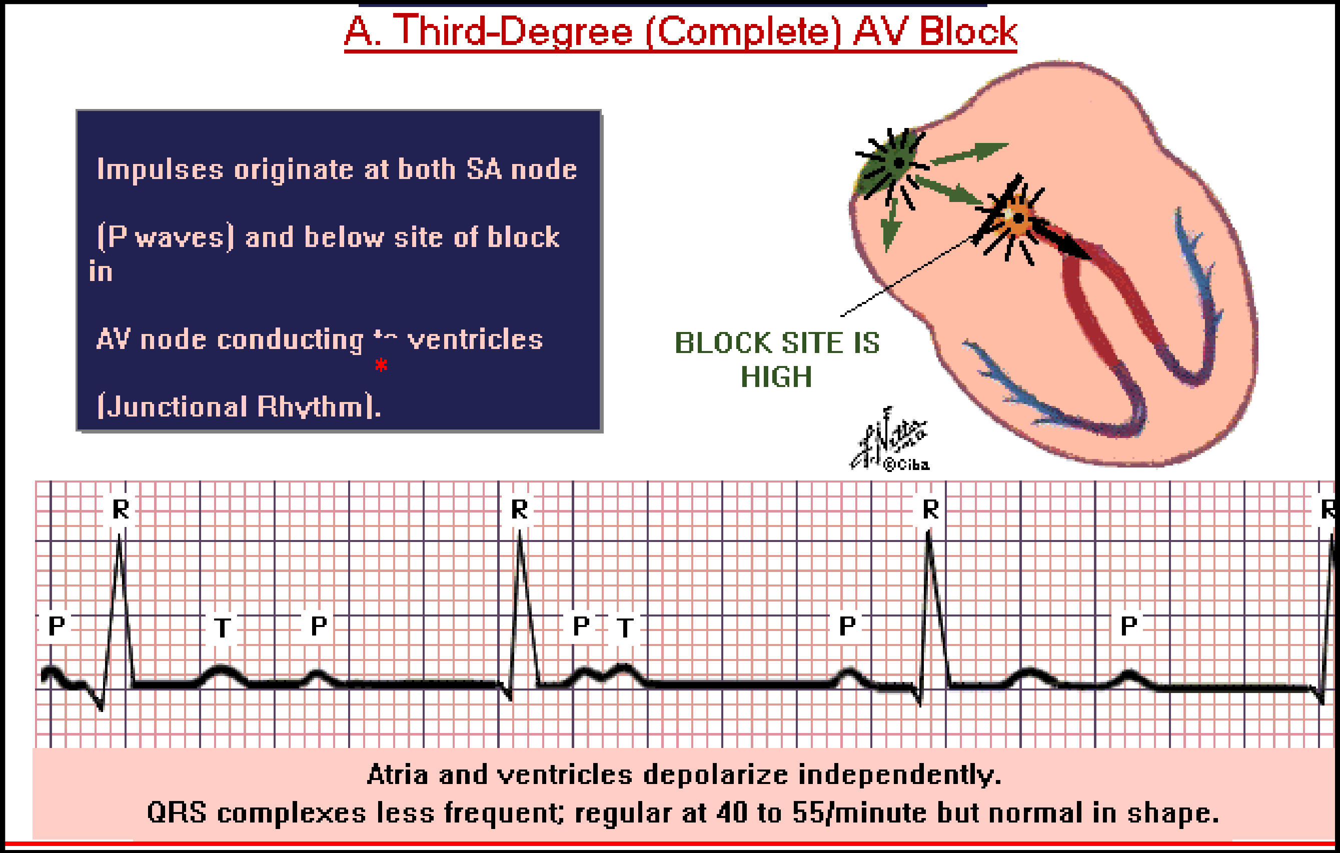


Atrio-ventricular conduction :

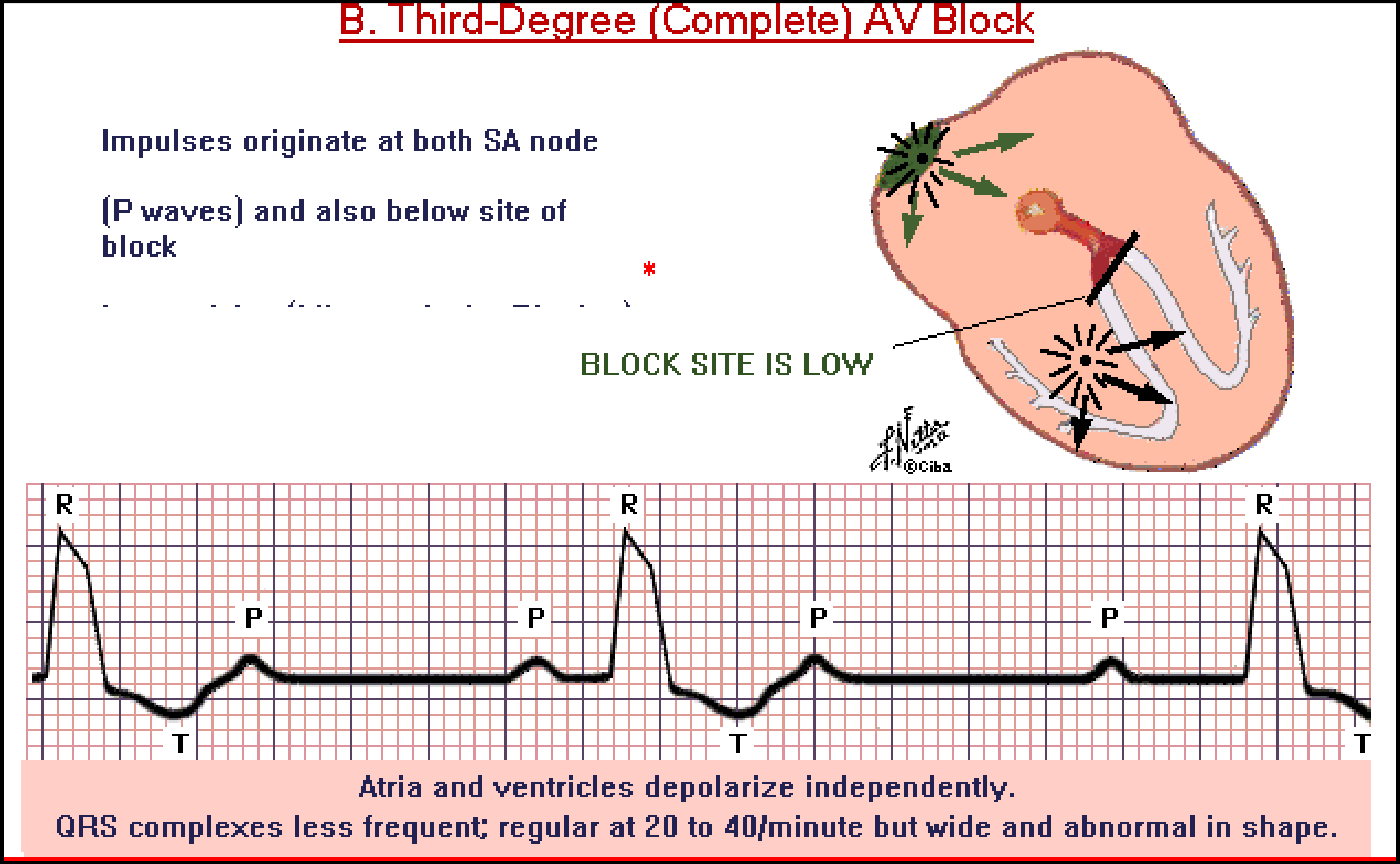
P wave never related to QRS



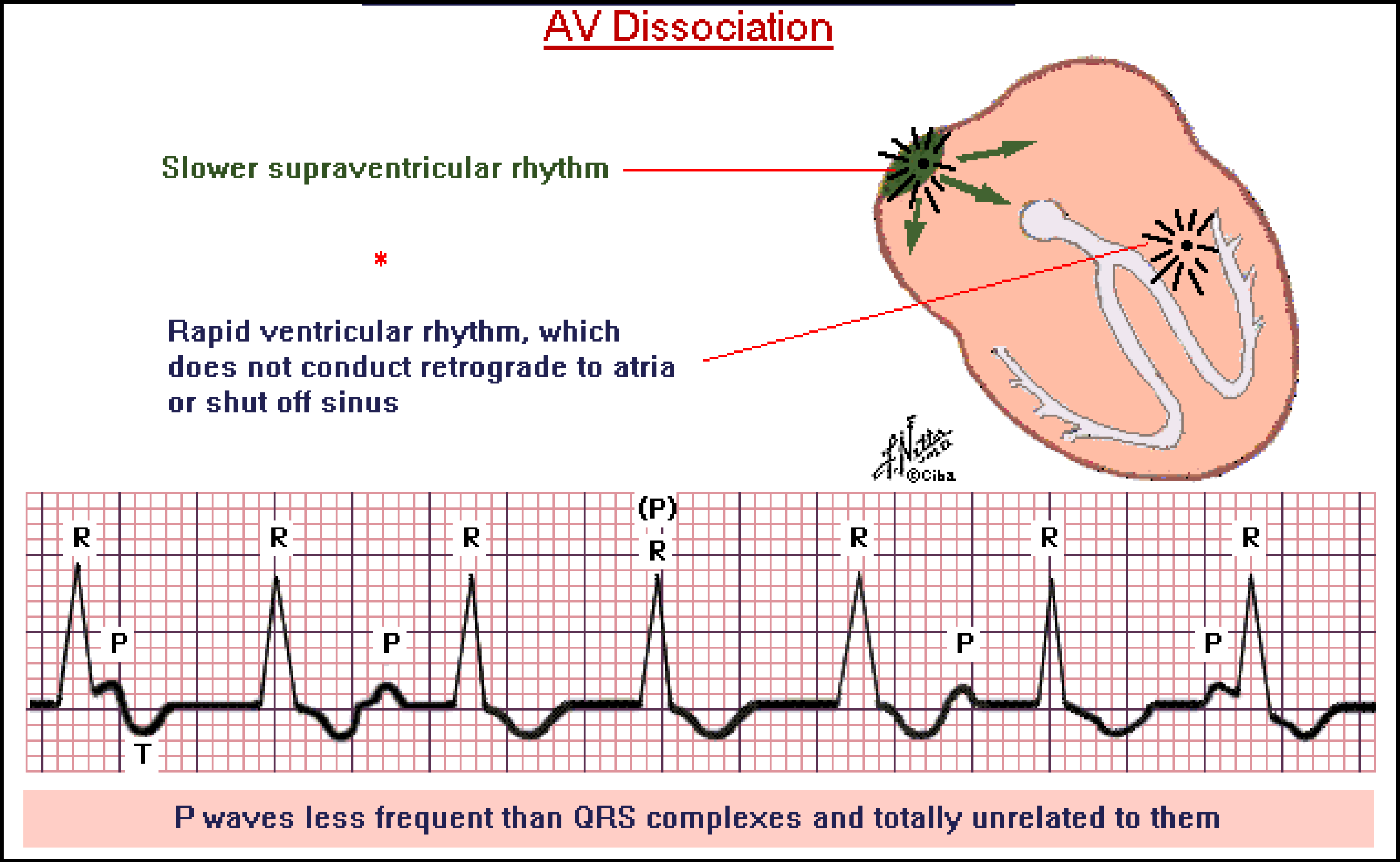
P wave never related to QRS



P wave never related to QRS

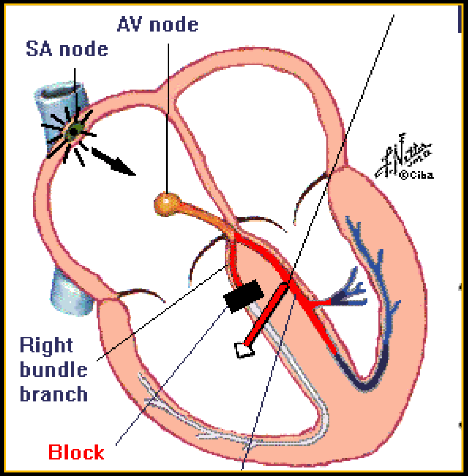


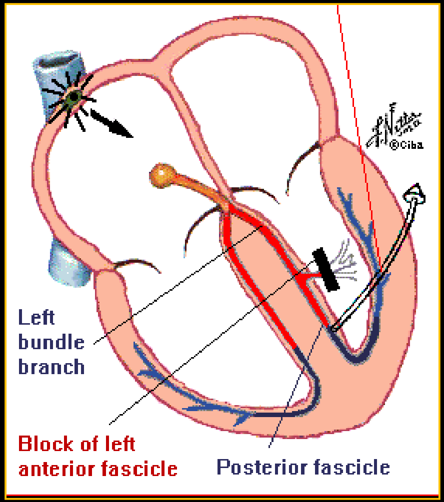
P wave never related to QRS

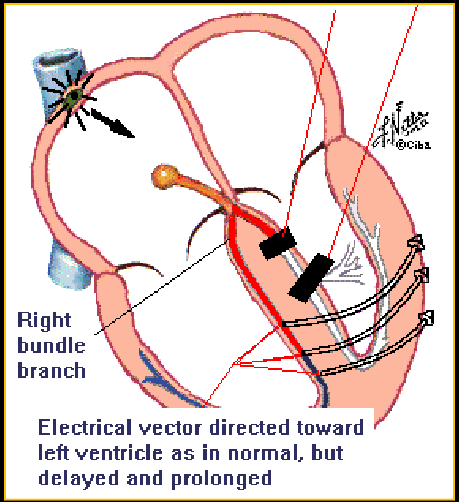


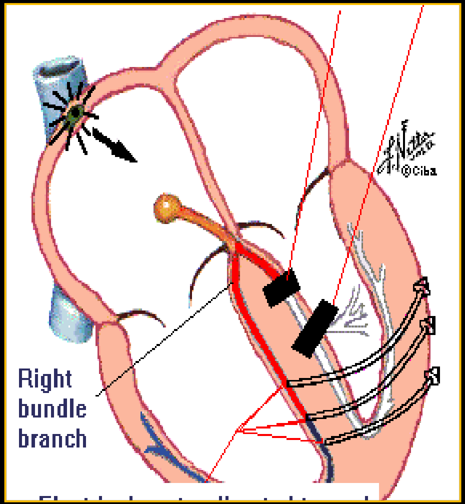
Intra-ventricular Conduction Defects

Right bundle branch block
Left bundle branch block
Left anterior hemiblock
Left posterior hemiblock

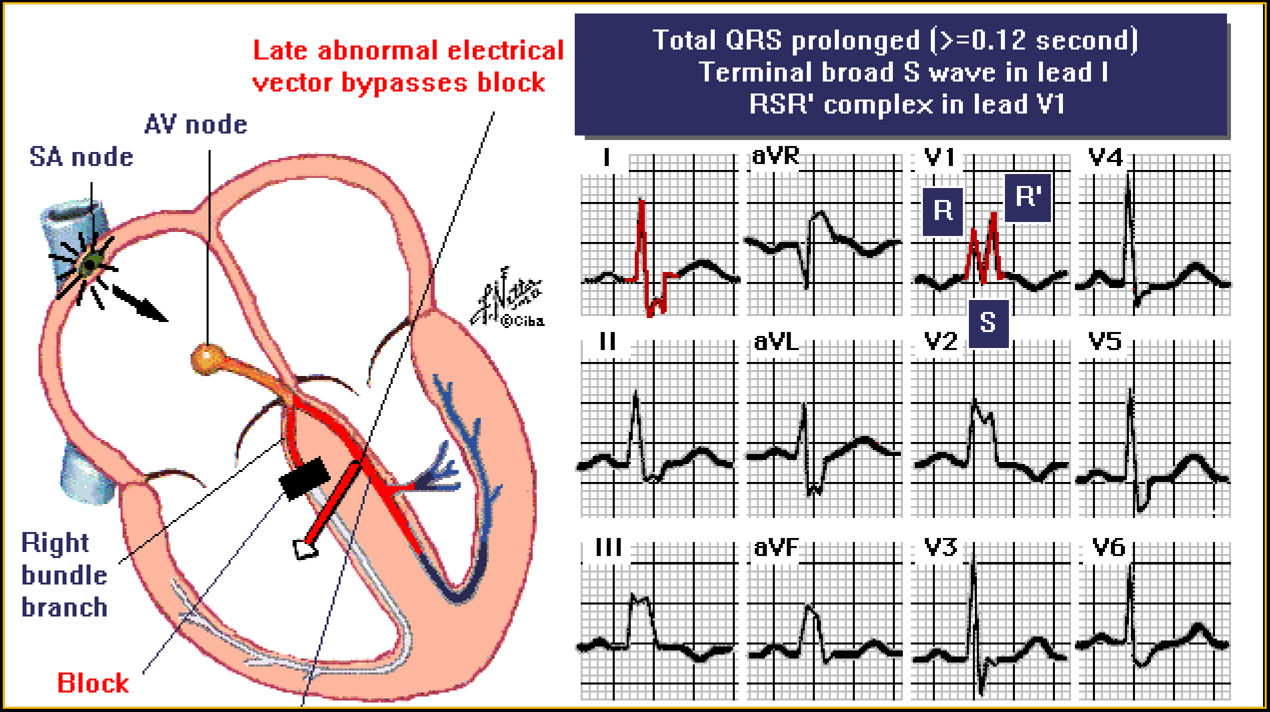




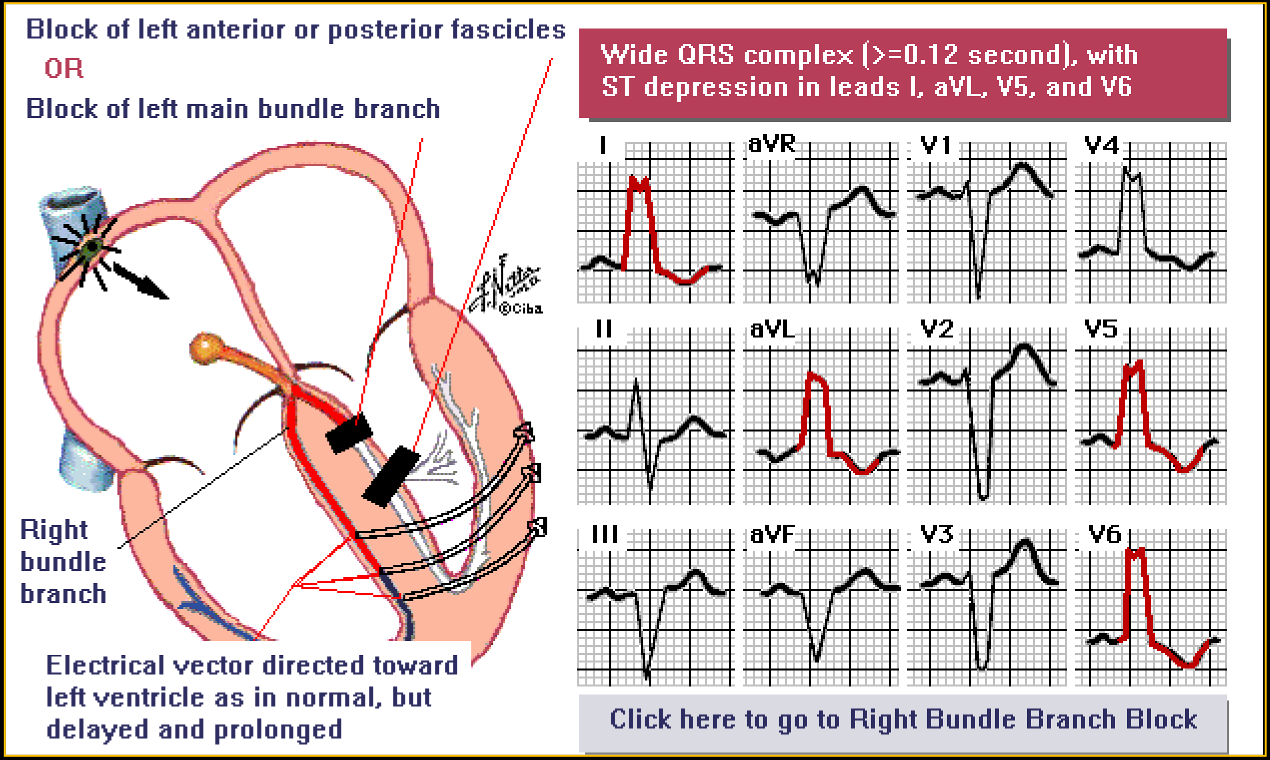




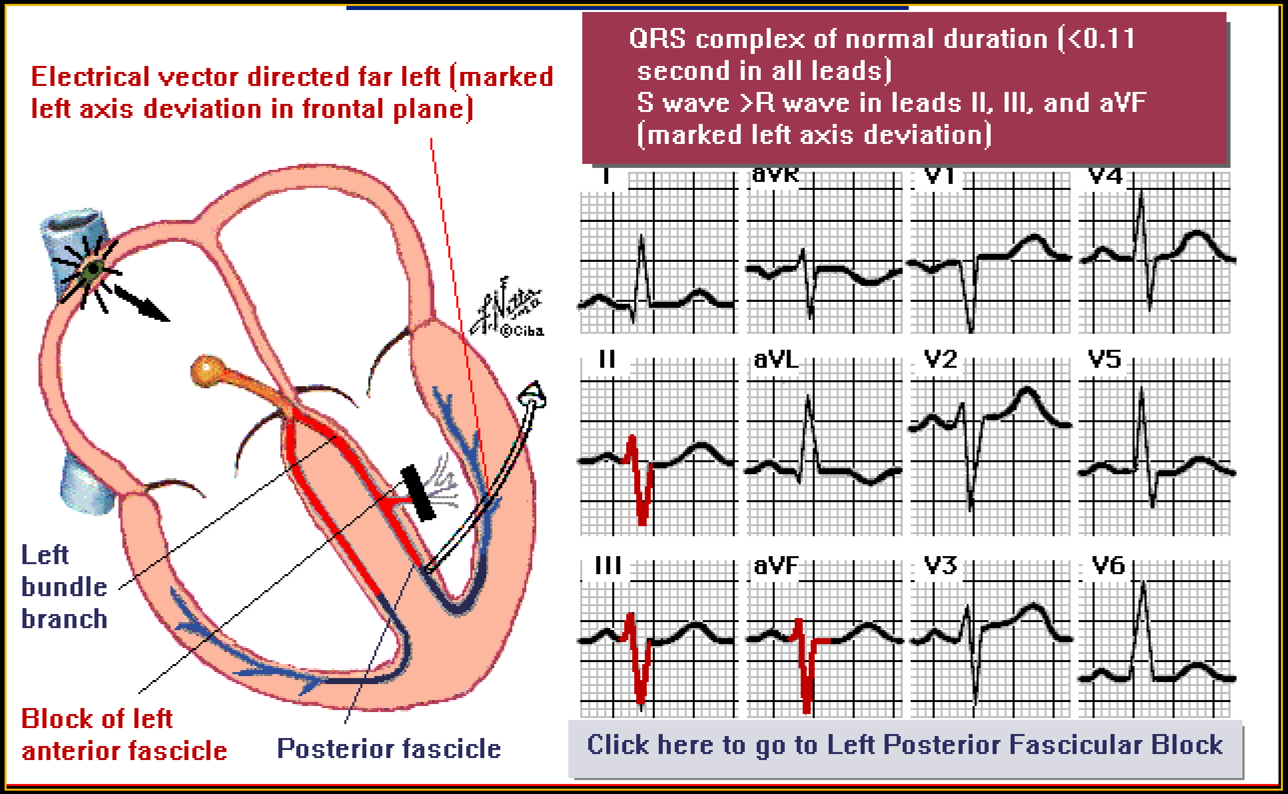
Right bundle branch block



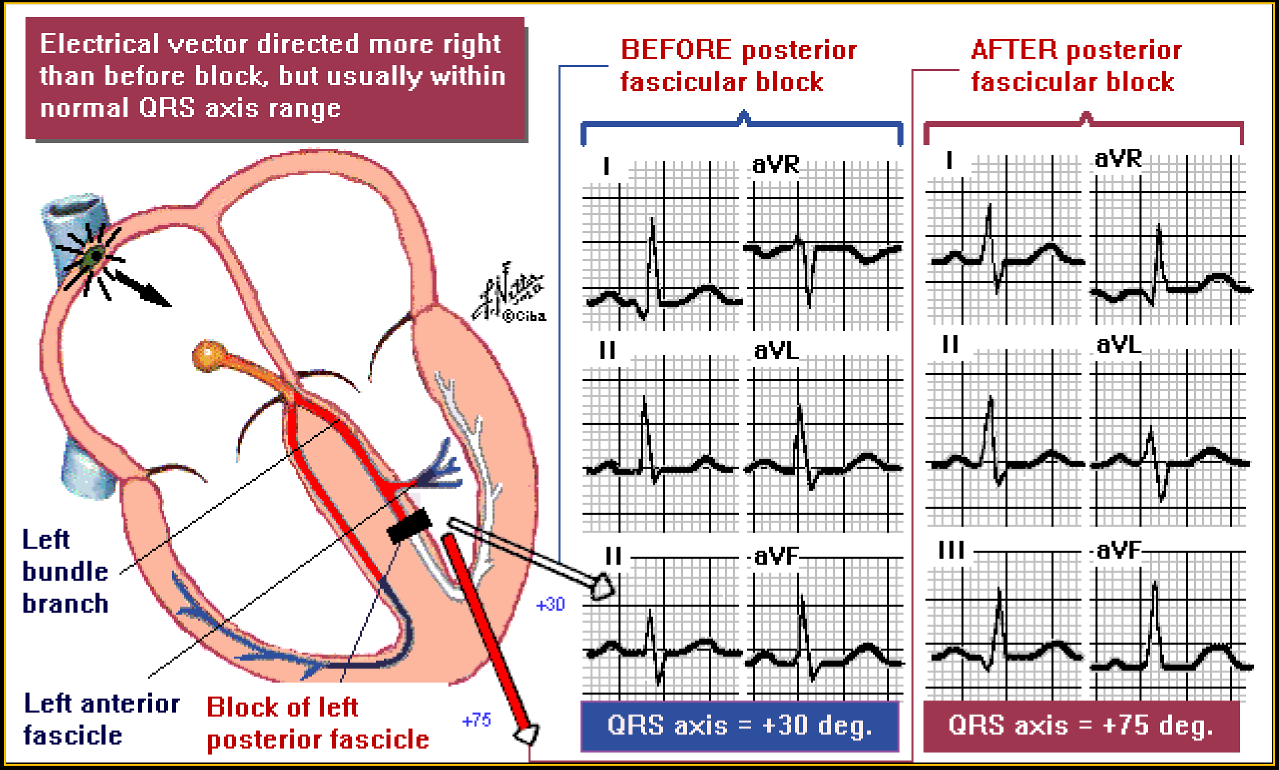
Left bundle branch block



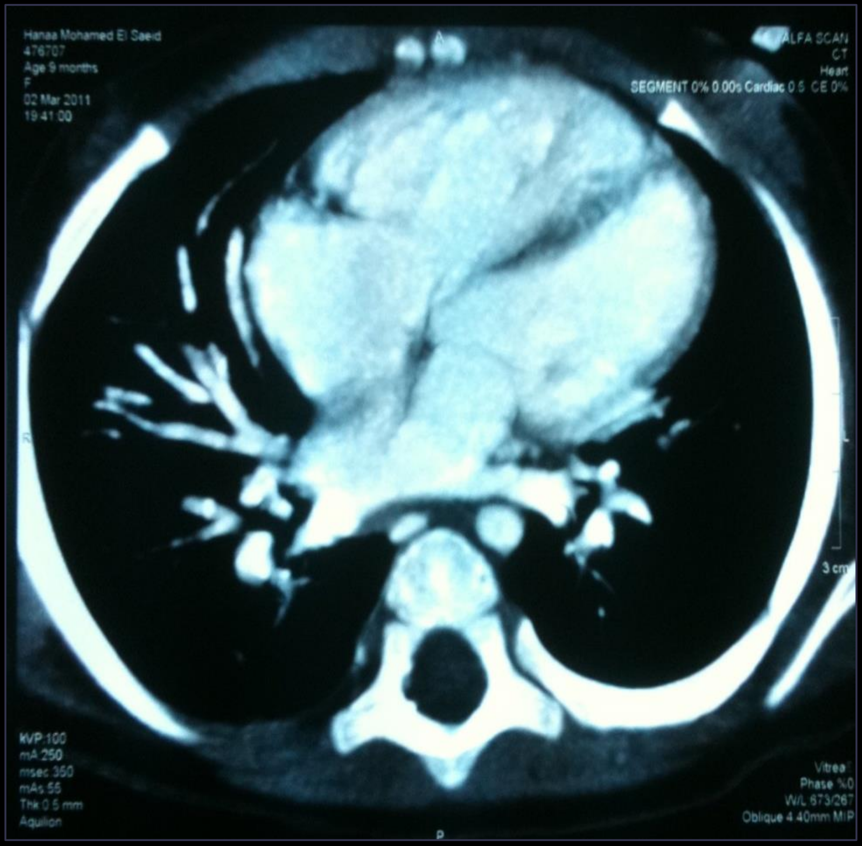
Left anterior hemiblock



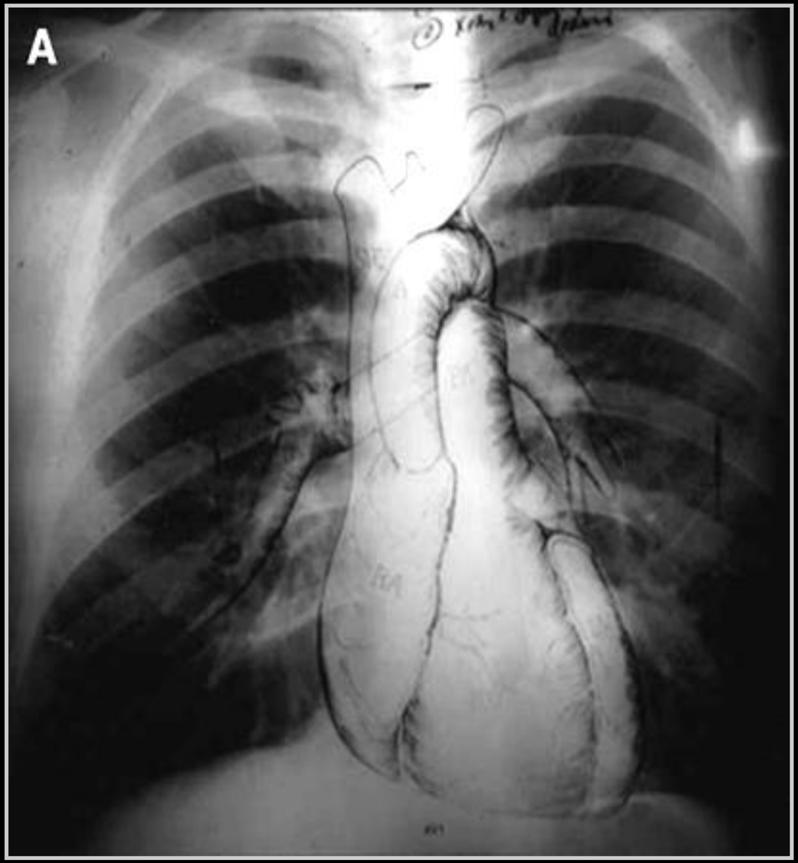
Left posterior hemiblock



V- Chamber Enlargement



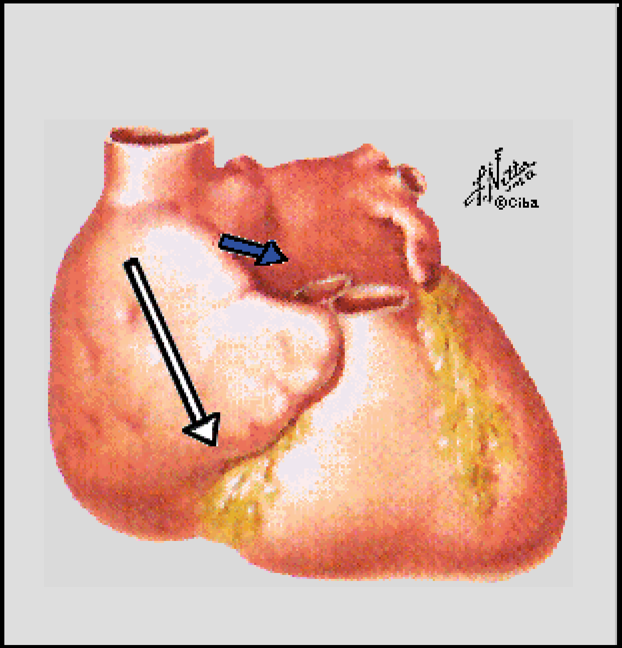
Hanaa Mohamed El Saeid
476707
Age 9 months
F
02 Mar 2011
19:41:00
A
ALFA SCAN
CT
Heart
SEGMENT 0% 0.00s Cardiac 0.5 CE 0%
3 cm
kVP:100
mA:250
msec:350
mAs:55
Thk 0.5 mm
Aquilion
Vitrea
Phase %0
W/L 673/267
Oblique 4.40mm MIP
P



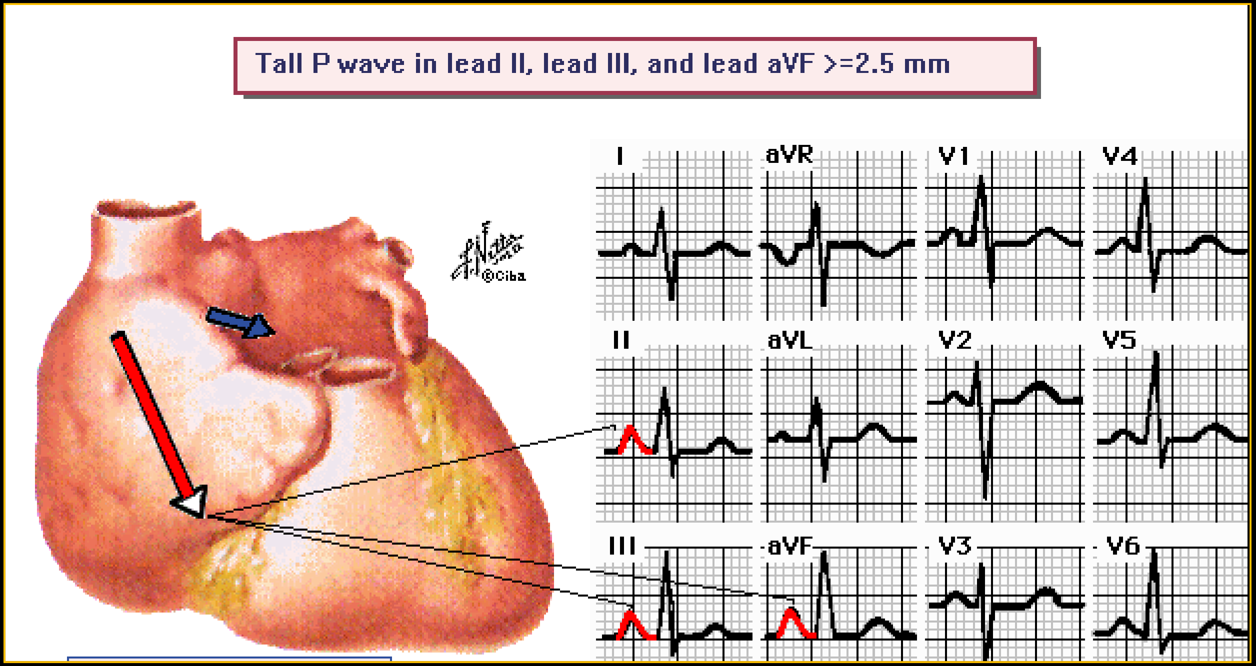
A

Chamber Enlargement

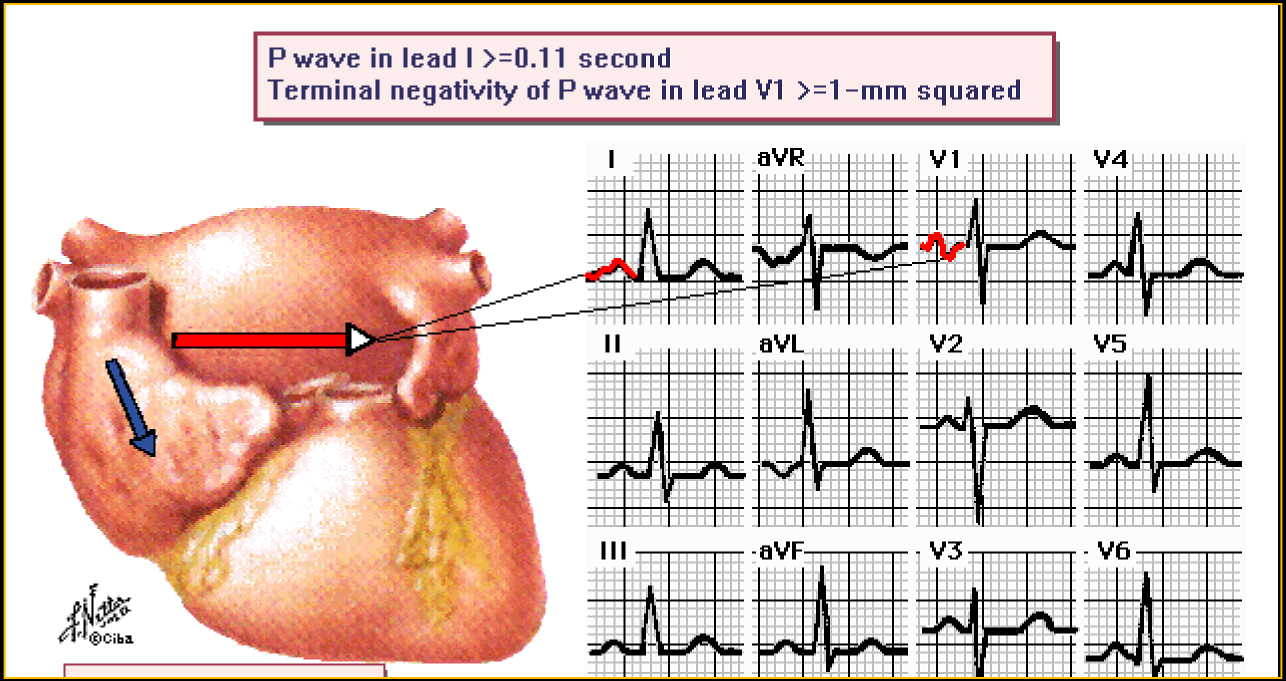
Right atrial enlargement
Left atrial enlargement
Right ventricular hypertrophy
Left ventricular hypertrophy



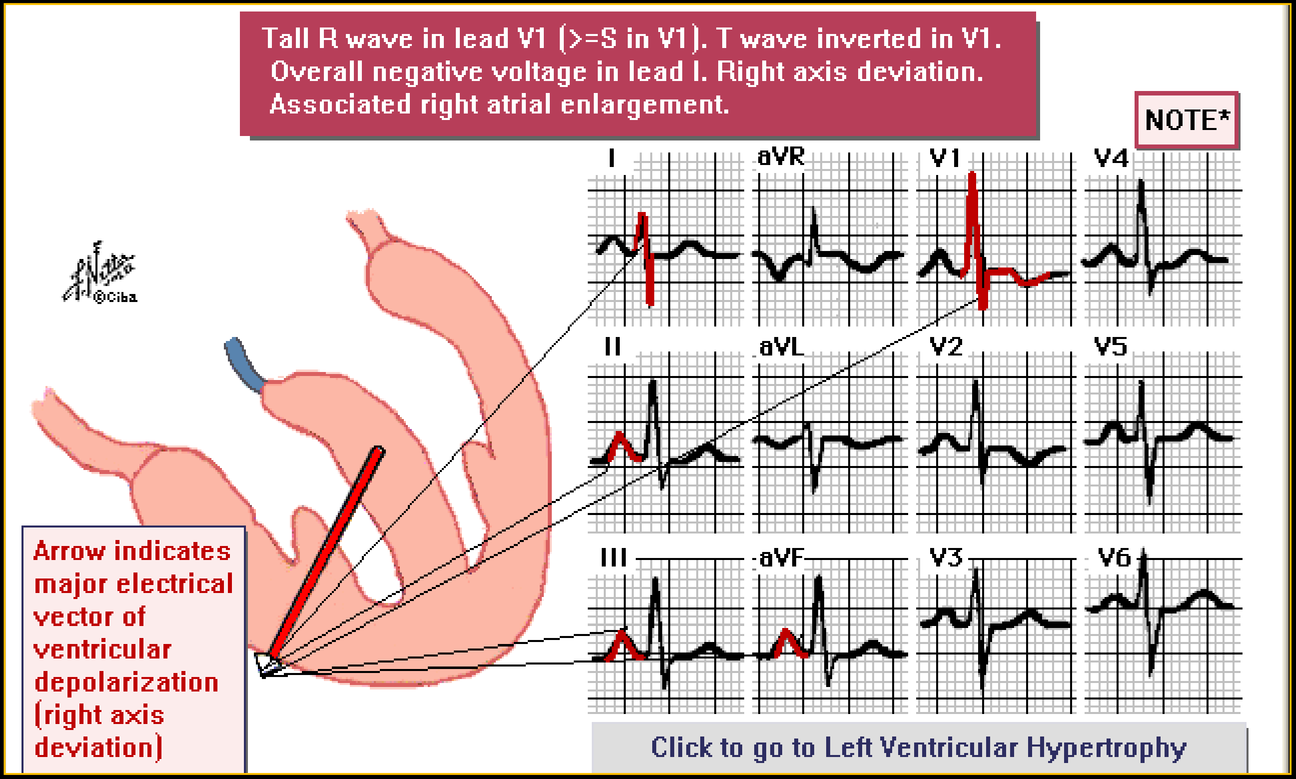
Right atrial enlargement



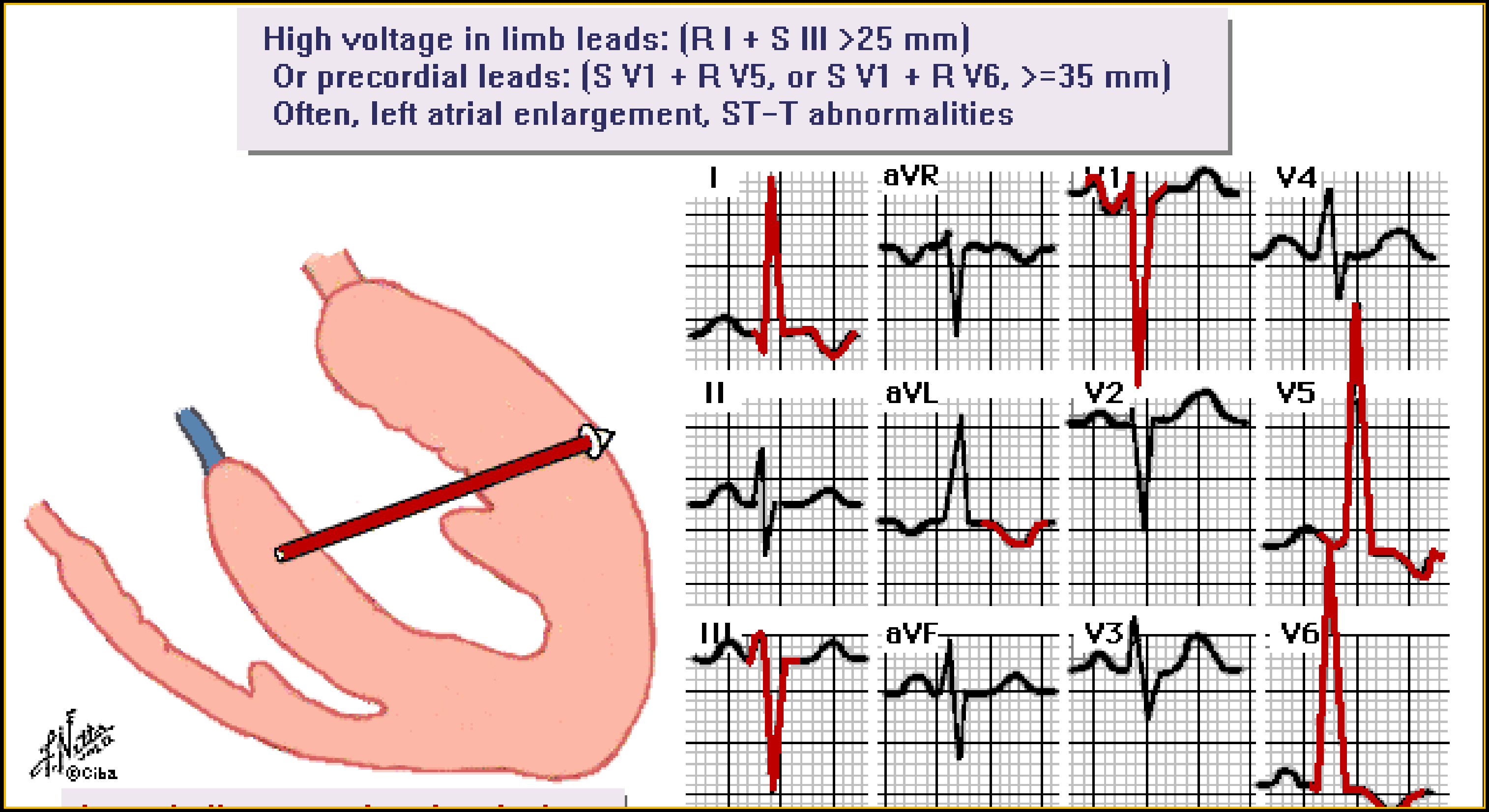
Left atrial enlargement



Right ventricular hypertrophy

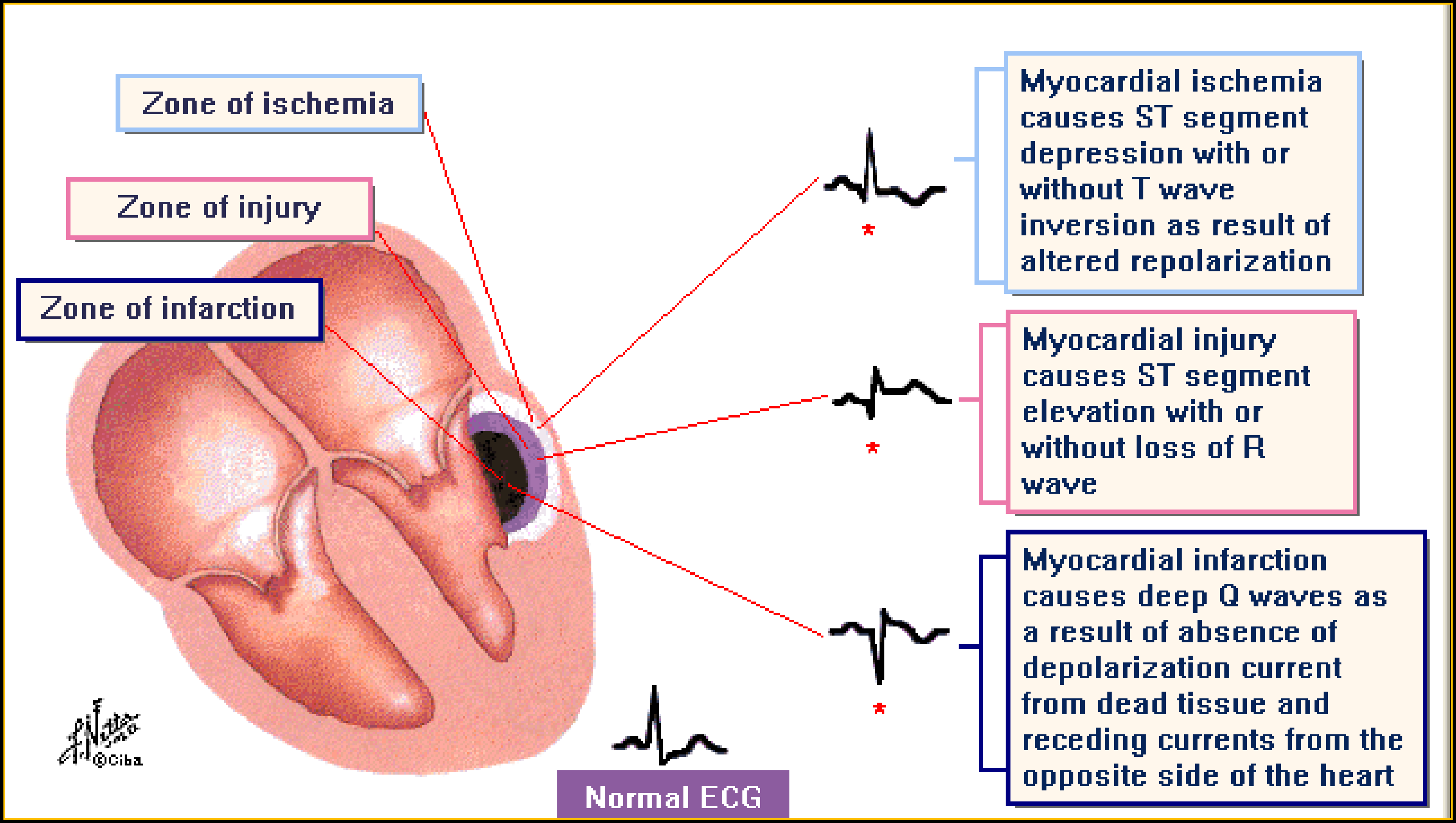


Left ventricular hypertrophy

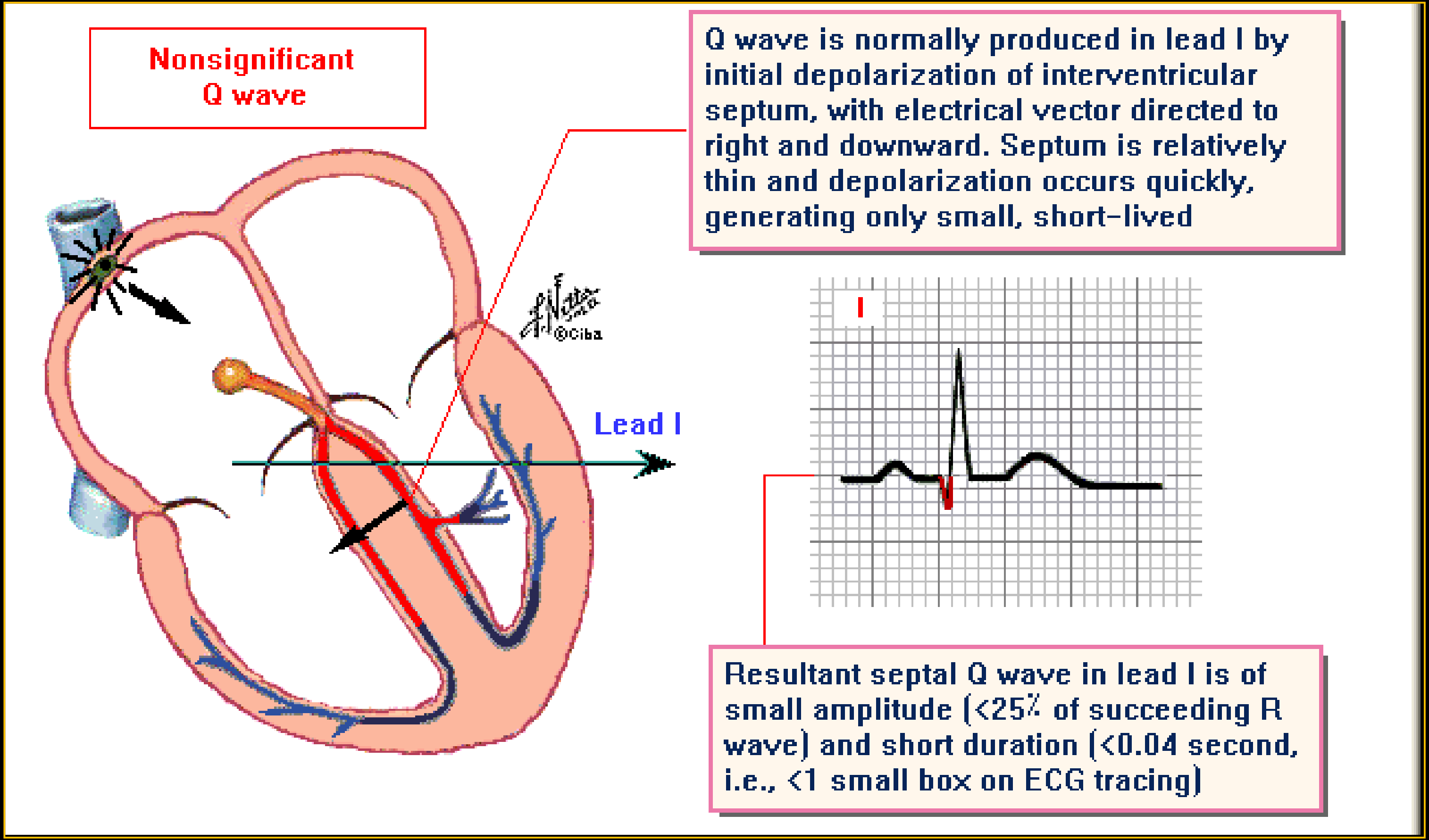


VI- Myocardial ischemia and infraction

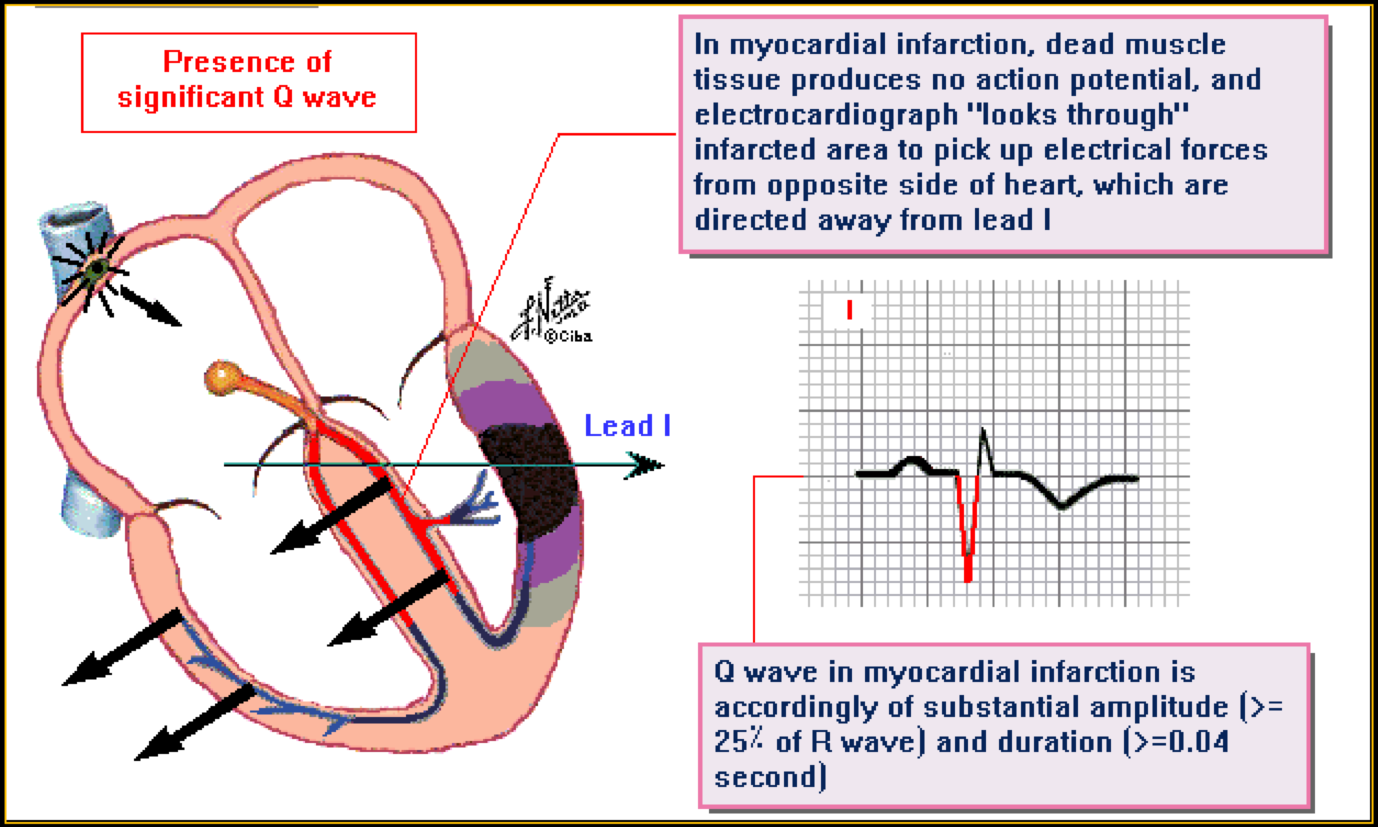
Myocardial ischemia or injury or infarction



Nonsignificant Q wave

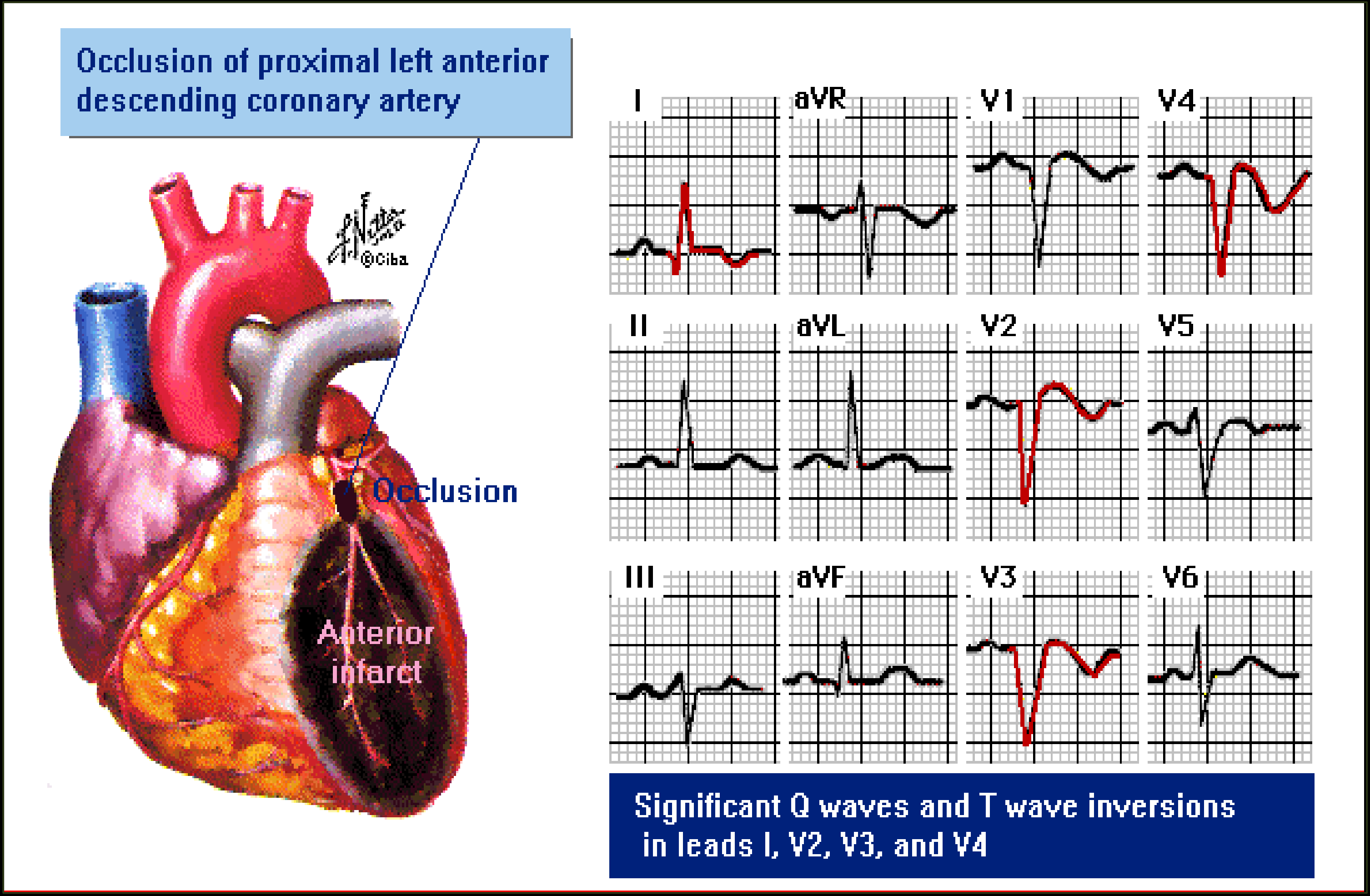


Significant Q wave



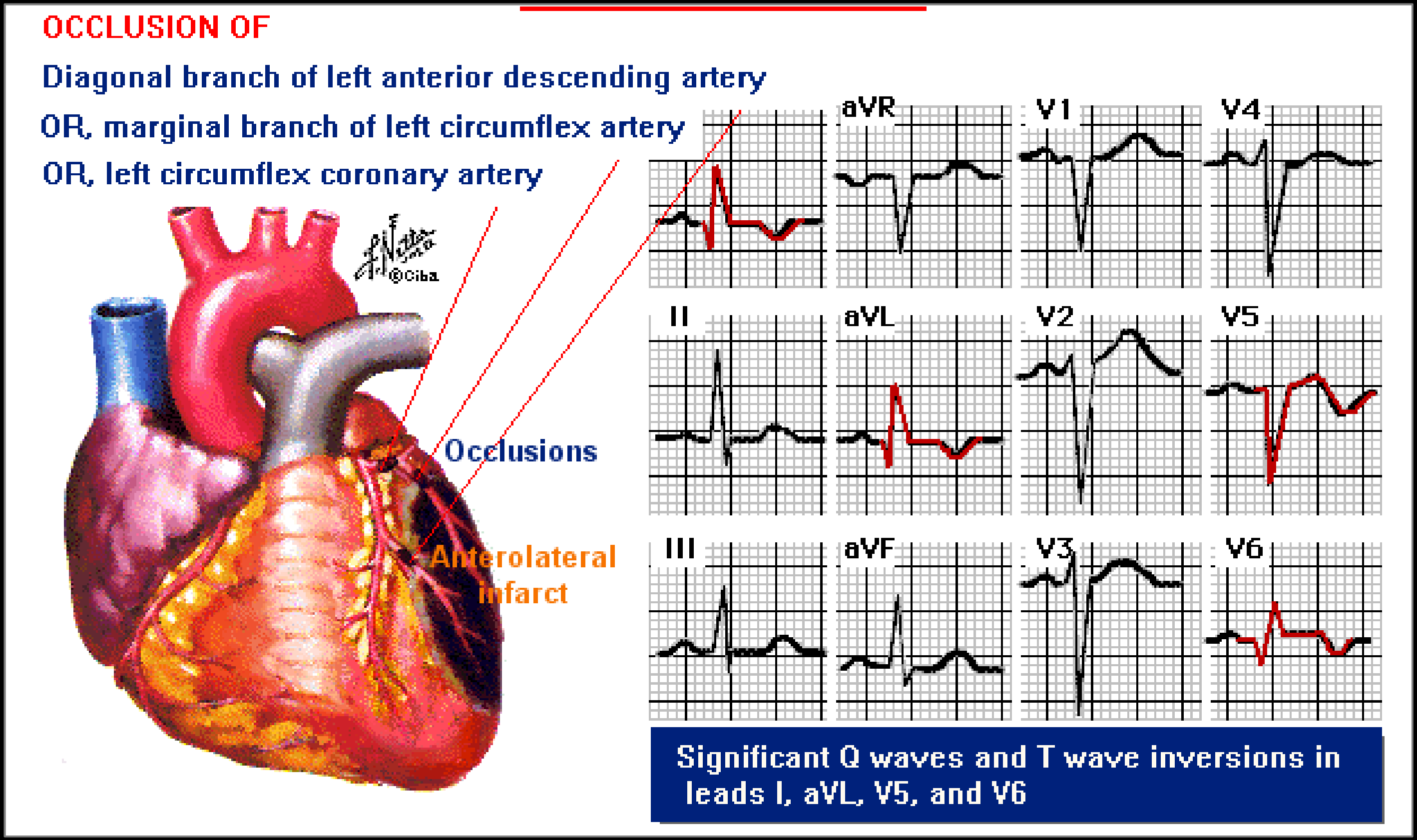
Localization of Infarction:

Anterior infarction

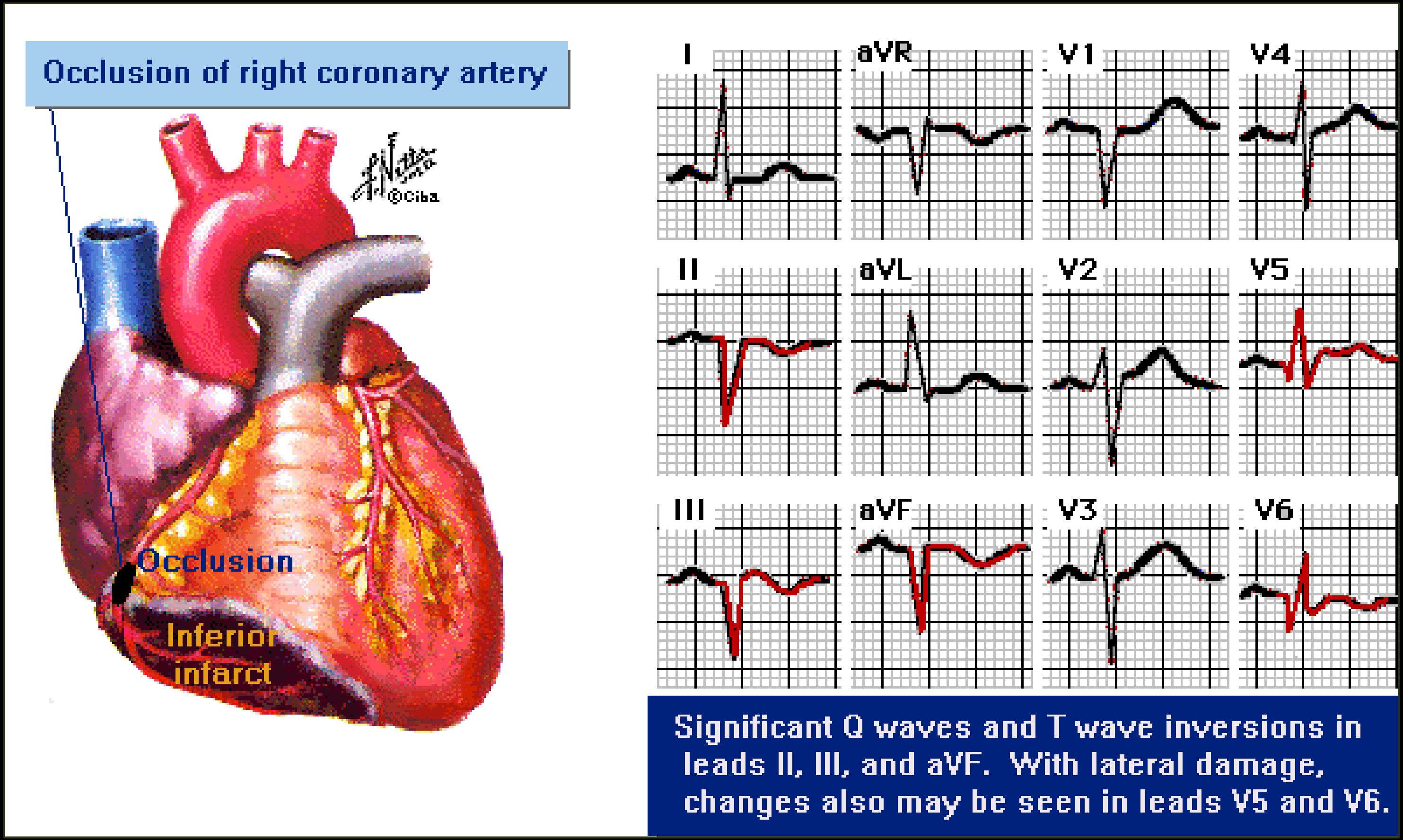


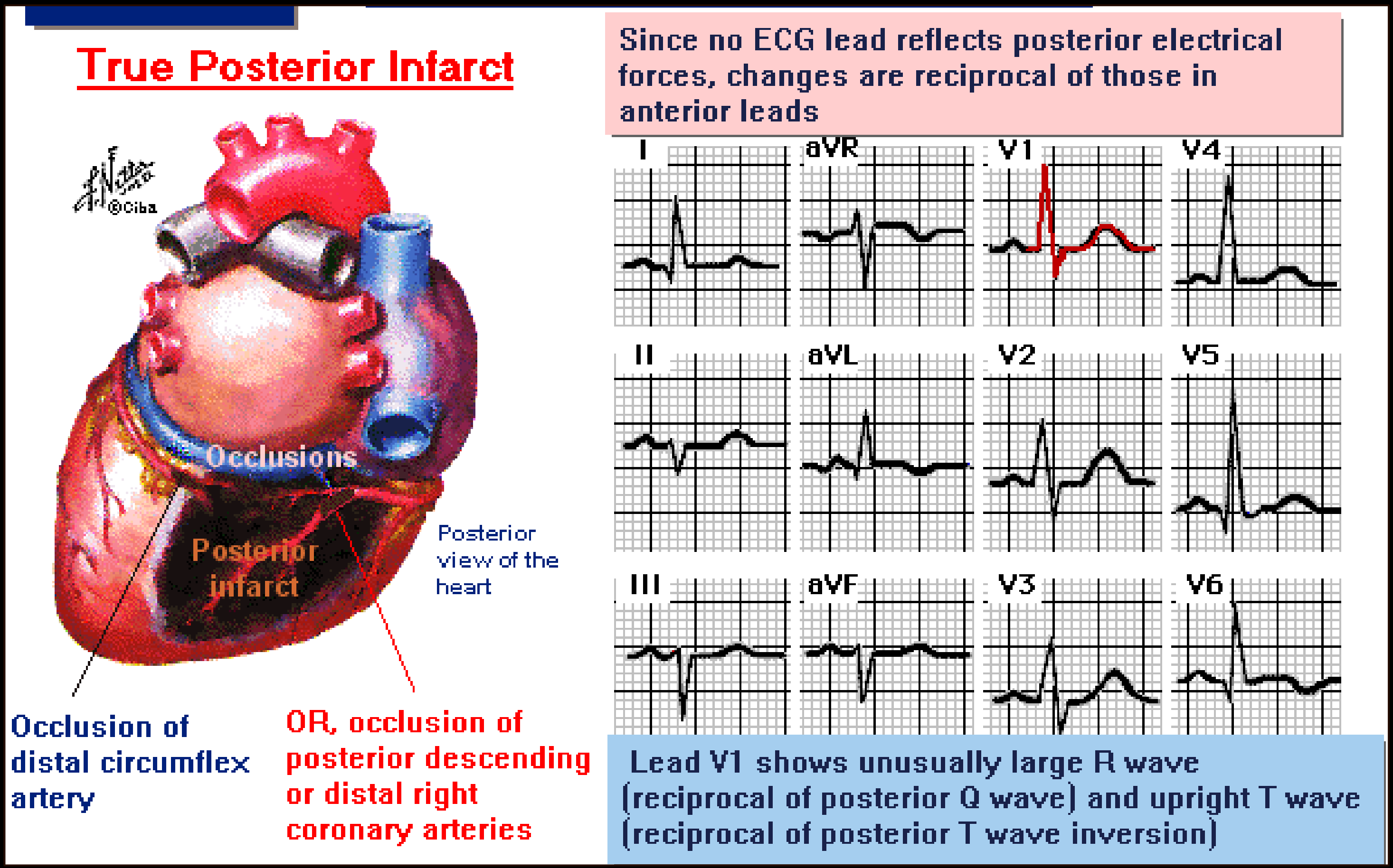
Localization of Infarction:

Anterlateral infarction



Localization of Infarction:
Inferior infarction





True Posterior Infarct
Since no ECG lead reflects posterior electrical forces, changes are reciprocal of those in anterior leads
©Ciba
Occlusions
Posterior infarct
Posterior view of the heart
Occlusion of distal circumflex artery
OR, occlusion of posterior descending or distal right coronary arteries
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
Lead V1 shows unusually large R wave (reciprocal of posterior Q wave) and upright T wave (reciprocal of posterior T wave inversion)

Thank you